MILK PRODUCTION IN THE TROPICS

(With special reference to the Philippines)

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(OR FIGURES OR PLATES)

CHAPTER 1

INTRODUCTION

Milk for direct human consumption and for manufacturing milk products is obtained from many kinds of domestic livestock, but approximately 90 per cent of the world's supply is produced by various types of domestic cattle (McCabe, 1955). The proportion of the total milk produced by domestic livestock other than cattle as reported by Payne (1957) is probably higher in tropical than in temperate countries, but in tropical countries cattle undoubtedly still produce most of the milk. In terms of livestock units, 70 per cent of the world's cattle and buffalo population is located in the developing countries (De Guzman, 1975), but the production of these countries is only 21 to 34 per cent of the world milk and beef output, respectively. This alarmingly low animal production in most developing countries, aggravated by a generally high rate of population growth where already 74 per cent of the world's human population is found, accounts for the low per capita protein intake of animal origin in these developing countries.

Achieving efficient milk production in tropical countries is widely recognised as a particularly difficult problem. According to McCabe (1955), the world produces only enough milk to meet 60 per cent of the world population's minimum dietary needs, but there are surpluses in some areas and shortages in others. This is because countries in the temperate zone contain 40 per cent of the world's population but produce 85 per cent of the world's milk. In fact, in temperate countries there is an average of more than 250kg of milk per head available, while in tropical countries there is only about 30kg.

The production, handling and treatment of milk and milk products in warm climatic regions of the world involve some specific problems which differ from those encountered in the temperate climatic zones. In most warm countries, as concluded by Rice (1965), dairying is still largely unorganized and primitive and is devoted chiefly to producing either within the cities or in their local environment, raw milk for consumption by urban populations. Most of the cows' milk (Eusebio, 1967) is consumed in liquid form, either raw, pasteurized or sterilized.

In the Philippines which is a predominantly agricultural country, consumption of milk and milk products is generally low (Eusebio, 1978). Because of this situation, the demand for dairy products has to be satisfied through importation, which results in a great drain on the country's foreign exchange. These importations also undermine the national development goals for self-sufficiency in these food commodities, and ultimately, the government drive against protein malnutrition which is a well-recognised problem in the country today.

The Food and Nutrition Research Council (FNRC) of the Philippine Government set a recommended daily per capita food allowance in terms of whole milk of 90 grams, or about 32.85kg per capita per year. However, surveys by the Special Studies Division (SSD), Department of Agriculture, showed that a weighted average consumption per capita per year of milk products is 25.68kg in milk equivalent. This accounts for only 78 per cent of the recommended daily intake.

It is the purpose of this dissertation to discuss the existing conditions in dairying as well as problems in increasing milk production in tropical countries, particularly the Philippines. In addition, it is hoped that at the end of this report recommendations can be made, which, if implemented, may well help to resolve some of the problems which beset dairying under tropical countries.

CHAPTER II

HUMAN REQUIREMENTS FOR MILK

Milk as defined by Folley *et al.*, (1973) is "the physiological secretion of the mammary gland of mammals to provide nourishment for their young". Throughout history, man has recognized the value of milk and milk products as food not only for the young but also for adults. Scmidt and Van Vleck (1974) also defined milk as "a nature's most perfect food and the sole source of food of most new-born". For human infants, milk is the only source of nutrients for the first two or three months of life, and in many countries milk plays a major role in the diet of the growing child. Milk and milk substitutes are also important during early growth of most domesticated mammals. In addition, milk can be a valuable source of nutrients for mature people especially the elderly. Over much of Southeast Asia, except India, traditionally milk has not been accepted as a basic human food (Warner, 1951). Then Wagan (1970) says that in the Philippines milk is not considered as an indispensable food. On the other hand, in some tropical areas of Africa, the Americas and the West Indies, there have not usually been strong inhibitions to the use of animal milk and its products. Milk and milk products have always been used in the human diet in India (Warner, 1951) where they are considered very important in the human diet even though the supply has been inadequate.

Hippocratus recorded his principles of medical science some 400 years before the birth of Christ and is generally recognized as the "Father of Medicine". His nutritional wisdom, and his observation related to the nutritional contributions of milk to man, were conveyed to us in the early-recorded statement that "Milk is the most nearly perfect food".

Cattle are the primary producers of milk in most countries, although water buffaloes, goats and sheep are principal producers of milk in some Asian and African countries.

It was reported by Schmidt and Van Vleck (1974) that the domestication of cattle began somewhere in Asia or Northeast Africa between 6,000 BC and 8,000 BC. Before the cow was domesticated, it was probably hunted by primitive man. Over the years, the cow has been used as a beast of burden, source of food, object of worship, source of sacrificial offerings and a subject of mythology. The people of India were raisers of cattle as early as 2,000 BC. Butter was used as food and as a holy offering to the Gods, when changed into a ghee (butter oil). In Ancient Greece and in Rome, most of the milk came from sheep. Both countries used butter as ointments and medicants. The major developments in dairy production from the earliest era to the middle 1850's occurred in Europe. Most of currently important dairy breeds in the United States and Europe originated there.

2.1 Milk Composition

Chemically, milk may be defined (Folley *et al.*, 1973) as a "complex mixture of fats, proteins, carbohydrates, minerals, vitamins and other miscellaneous constituents dispersed in water". Table 1 lists the major constituents and gross composition of milk.

TABLE 1: The Gross Composition of Milk Showing Average Percentage by Weight of the Major Constituents and Normal Variations for Mixed Herd Milk

Constituent	Average content (%)	Normal variation (%)
Water	87.20	82.0-89.0
Fat	3.70	2.5-6.0
Casein	2.80	2.3-4.0
Lactalbumins and Lactoglobulins	0.70	0.4-0.8
Lactose	4.90	3.5-6.0
Minerals	0.70	0.6-7.5
	100.00	

Certain common terminologies are used when describing these constituents either singly or in groups. The fat is often referred to as milkfat. The dry matter of milk is known as the total solids, and the group of proteins, carbohydrates and minerals is called the solid-not-fat, or, occasionally, the serum-solids.

Although milk is liquid and often considered a drink (Campbell and Marshall, 1975) it contains an average of 13 per cent solids, an amount comparable with the solid content of many other foods. Hence, more appropriately milk should be regarded as a food.

Table 2 shows the milk composition and growth rates of selected mammals, which, of course, include milk in their diet. The relatively low percentages of protein and ash in a woman's milk compared with milk of the cow and dog should be noted. It requires about 180 days for the new-born infant to double its birthweight compared with only 47 and 8 days for the calf and puppy, respectively. The parallel is noted then, between growth rate of the young concentration in milk of protein and

TABLE 2: Milk Composition and Growth Rates of Selected Mammals

Mammal	Milk Composition, in % Protein	Lactose	Milk Fat	Ash	Total Solids	Time, in days for the newborn to double its weight
Woman	1.6	7.0	3.7	0.2	12.5	180
Mare	2.2	5.9	1.3	0.4	9.8	60
Cow	3.3	5.0	4.0	0.7	13.0	47
Goat	3.7	4.2	4.1	0.8	12.8	19
Sow	4.9	5.3	5.3	0.9	16.4	18
Dog	7.1	3.7	8.3	1.3	20.4	8

Source: J.R. Campbell and J.F. Lasley, *The Science of Animals That Serve Mankind*, McGraw-Hill, New York, 1969, pp. 38, 288.

ash in a woman's milk compared with milk of the cow and dog should be noted. It requires about 180 days for the newborn infant to double its birthweight compared with only 47 and 8 days for the calf and puppy, respectively. The parallel is noted then, between growth rate of the young concentration in milk of protein and ash, the nutrients needed to develop muscle and skeleton tissue in the animal body.

2.2 Milk Constituents

Broadly speaking, the nutritive value of milk depends on its composition (Kon and Cowie, 1961). Table 3 shows the main groups of milk constituents.

At the time of its secretion milk contains two liquid phases, fat and water, between which are partitioned at least forty chemical compounds. Dissolved in the fat, or beld at the fat globule surface, are numerous compounds such as phospholipids, sterols, carotenoids and fat-soluble vitamins, and some of the minerals; it also carries in colloidal form proteins

TABLE 3: The Main Groups of Milk Constituents

- Milk
  - Non-fatty solids
    - Nitrogenous substances
      - Non-protein
      - Protein
        - Casein
        - Albumin
        - Globulin
        - Proteose-peptone
        - Other (Enzymes)
    - Lactose
    - Water-soluble vitamins
    - Mineral matter
  - Water
    - (Dissolved CO_2, O_2, N_2)
  - Fatty fraction
    - Triglycerides
    - Other fat-soluble compounds
      - Phospholipids
      - Sterols
      - Fat-soluble vitamins
      - Carotenoids

and the remainder of the minerals. Three physical states - solution, emulsion and colloidal suspension, are therefore in very intimate association, so intimate in fact that changes in any one are not without effect on one or both of the others.

The nutritional merits are indicated by the fact that daily consumption of a quart is approximately one litre, of cow's milk (Jenness and Palton, 1959) provides an average man with approximately all the fat, calcium, phosphorus and riboflavin; one half of the protein; one third of the vitamin A, ascorbic acid, and thiamine; one fourth of the calories and, with the exception of iron, copper, manganese and magnesium, all of the minerals needed daily as shown on Table 4.

2.3 Nutrients of Milk

In this modern age, milk is considered important in the diet (Folley *et al.*, 1973) because of its ingredients, particularly protein, calcium and riboflavin. The most important is protein which provides many of the essential amino acids that are often deficient in the cereal grains commonly used for food. The usual recommended quantity of one quart of milk per day supplies all of the protein requirements of children up to 14 years of age. Calcium is the nutrient most likely to be lacking in the diets of those who do not consume milk or milk products. Adequate calcium requirement of a nursing mother is 1.3 grams. The recommended quart of milk contains approximately 1.17 grams of calcium; therefore this volume per day meets almost all of the calcium needs of pregnant and lactating women. Calcium is especially important in the diet of the elderly because calcium diffuses

TABLE 4: Some Nutritive Properties and Components of Milk

Nutrient	Amt. in 1 Qt. Avg. Milk	Amt. per 100 kcal. Portion	Requirements per Day		Daily Consumption of Milk (qt.) Necessary to Satisfy Requirement			
			Adults	Children*	Adults	Classification†	Children*	Classification†
Energy	650 kcal.		3000 kcal.	2500 kcal.	4.6		3.8	
Protein	33 g.	5.0 g.	70 g.	70 g.	2.1	Good	2.1	Good
Calcium	1.12 g.	0.17 g.	0.8 g.	1.2 g.	0.71	Excellent	1.1	Excellent
Phosphorus	0.94 g.	0.14 g.	0.9 g.	1.2 g.	1.0	Excellent	1.3	Excellent
Iron	2.26 mg.	0.35 mg.	12 mg.	12 mg.	5.3	Fair	5.3	Fair
Copper	0.26 mg.	0.04 mg.	1.0 mg.	1.0 mg.	4.0	Fair	4.0	Fair
Iodine	0.04-0.07 mg.		0.05 mg.	0.15 mg.				
Vitamin A	500-100 I.U. winter 2000-3000 I.U. pasture	75-460 I.U.	5000 I.U.	5000 I.U.	1.7-10.0	Fair to good	1.7-10.0	Fair to good
Vitamin D	5-15 I.U.	0.75-2.25 I.U.		400-450 I.U.			30-90	Poor
Thiamine	0.35-0.40 mg.	0.06 mg.	2.0 mg.	1.2 mg.	5.0	Fair to good	3.0	Fair to good
Riboflavin	1.5 mg.	0.23 mg.	2.5 mg.	1.8 mg.	1.7	Excellent	1.2	Excellent
Niacin	0.2-1.2 mg.	0.03-1.8 mg.	20 mg.	12 mg.	15-100	Poor	10-60	Poor to fair
Pantothetic acid	2.9 mg							
Ascorbic acid	20 mg. (fresh milk) 5 mg. (past. milk)	0.75 mg.	75 mg.	75 mg.	3.7-15	Poor	3.7-15	Poor

* Ten- to 12-year olds.
† Excellent-10% requirement furnished by amount furnishing not over 100 kcal. Fair-10% requirement furnished by 1 qt.
Good-10% requirement furnished by amount furnishings not over 200 kcal. Poor-less than 10% requirement furnished by 1 qt.

out of the bones unless it is consumed daily. If calcium diffuses out of the bones, porous bones develop this condition, which is known as osteoporosis, predisposes elderly people to fractures of the vertebrae and hips. Riboflavin and vitamin A are the vitamins most likely to be deficient in the human diet. A quart of milk per day supplies all of the riboflavin requirements of growing children and adults, except pregnant and lactating females. Almost all of the vitamin A requirements of infants less than one year of age, roughly 72 per cent of those of children 8 to 10 years, and 29 per cent of those of adults, are supplied by a quart of milk per day.

During pregnancy and lactation, women require additional protein (henderson, 1971) to supply that required first by the foetus and then later for milk production. Table 5 shows the recommended daily dietary allowances of protein and of other nutrients for healthy people of all ages.

In the same manner, the recommended daily intake for a 70 kg man are compared with nutrients supplied by one quart of milk (Table 6).

The essential amino acids shown in Table 7 are those which are necessary to maintain the nitrogen equilibrium of men and women (Henderson 1971). Children, especially, require adequate amounts of complete proteins. The above table shows that a pint of milk supplies the minimum daily requirements for women. Dietary variations and body stress may alter human requirements for amino acids.

Hence the following Table 8 shows that the major contribution to the diet is in the protein, calcium, vitamin B_2 and Vitamin A contained in dairy products.

TABLE 5: Recommended Daily Dietary Allowances[1,2] (Revised 1968) Designed for the Maintenance of Good Nutrition of Practically all Healthy People in the U.S.A.

								Fat-Soluble Vitamins			Water-soluble Vitamins							Minerals				
	Age[3] Years From Up to	Weight Kg	Weight Lb	Height Cm	Height In	kcal	Protein Gm	Vitamin A Activity IU	Vitamin D IU	Vitamin E Activity IU	Ascorbic Acid Mg	Folacin[4] Mg	Niacin[5] Mg Equiv	Riboflavin Mg	Thiamine Mg	Vitamin B6, Mg	Vitamin B12 µg	Calcium Gm	Phosphorus Gm	Iodine µg	Iron Mg	Magnesium Mg
Infants	0-1/6	4	9	55	22	kgx120	kgx2.2[6]	1,500	400	5	35	0.05	5	0.4	0.2	0.2	1.0	0.4	0.2	25	6	40
	1/6-1/2	7	15	63	25	kgx100	kgx2.0[6]	1,500	400	5	35	0.05	7	0.5	0.4	0.3	1.5	0.5	0.4	40	10	60
	1/2-1	9	20	72	28	kgx100	kgx1.8[6]	1,500	400	5	35	0.1	8	0.6	0.5	0.4	2.0	0.6	0.5	45	15	70
Children	1-2	12	26	81	32	1,100	25	2,000	400	10	40	0.1	8	0.6	0.6	0.5	2.0	0.7	0.7	55	15	100
	2-3	14	31	91	36	1,250	25	2,000	400	10	40	0.2	8	0.7	0.6	0.6	2.5	0.8	0.8	60	15	150
	3-4	16	35	100	39	1,400	30	2,500	400	10	40	0.2	9	0.8	0.7	0.7	3	0.8	0.8	70	10	200
	4-6	19	42	110	43	1,600	30	2,500	400	10	40	0.2	11	0.9	0.8	0.9	4	0.8	0.8	80	10	200
	6-8	23	51	121	48	2,000	35	3,500	400	15	40	0.2	13	1.1	1.0	1.0	4	0.9	0.9	100	10	250
	8-10	28	62	131	52	2,200	40	3,500	400	15	40	0.3	15	1.2	1.1	1.2	5	1.0	1.0	110	10	250
Males	10-12	35	77	140	55	2,500	45	4,500	400	20	40	0.4	17	1.3	1.3	1.4	5	1.2	1.2	125	10	300
	12-14	43	95	151	59	2,700	50	5,000	400	20	45	0.4	18	1.4	1.4	1.6	5	1.4	1.4	135	18	350
	14-18	59	130	170	67	3,000	60	5,000	400	25	55	0.4	20	1.5	1.5	1.8	5	1.4	1.4	150	18	400
	18-22	67	147	175	69	2,800	60	5,000	400	30	60	0.4	18	1.6	1.4	2.0	5	0.8	0.8	140	10	400
	22-35	70	154	175	69	2,800	65	5,000	-	30	60	0.4	18	1.7	1.4	2.0	5	0.8	0.8	140	10	350
	35-55	70	154	173	68	2,600	65	5,000	-	30	60	0.4	17	1.7	1.3	2.0	5	0.8	0.8	125	10	350
	55-75+	70	154	171	67	2,400	65	5,000	-	30	60	0.4	14	1.7	1.2	2.0	6	0.8	0.8	110	10	350
Females	10-12	35	77	142	56	2,250	50	4,500	400	20	40	0.4	15	1.3	1.1	1.4	5	1.2	1.2	110	18	300
	12-14	44	97	154	61	2,300	50	5,000	400	20	45	0.4	15	1.4	1.2	1.6	5	1.3	1.3	115	18	350
	14-16	52	114	157	62	2,400	55	5,000	400	25	50	0.4	16	1.4	1.2	1.8	5	1.3	1.3	120	18	350
	16-18	54	119	160	63	2,300	55	5,000	400	25	50	0.4	15	1.5	1.2	2.0	5	1.3	1.3	115	18	350
	18-22	58	128	163	64	2,000	55	5,000	400	25	55	0.4	13	1.5	1.0	2.0	5	0.8	0.8	100	18	350
	22-35	58	128	163	64	2,000	55	5,000	-	25	55	0.4	13	1.5	1.0	2.0	5	0.8	0.8	100	18	300
	35-55	58	128	160	63	1,850	55	5,000	-	25	55	0.4	13	1.5	1.0	2.0	5	0.8	0.8	90	18	300
	55-75+	58	128	157	62	1,700	55	5,000	-	25	55	0.4	13	1.5	1.0	2.0	6	0.8	0.8	80	10	300
Pregnancy						+200	65	6,000	400	30	60	0.8	15	1.8	+0.1	2.5	8	+0.4	+0.4	125	18	450
Lactation						+1,000	75	8.000	400	30	60	0.5	20	2.0	+0.5	2.5	6	+0.5	+0.5	150	18	450

[1]Anon. (1968) [2]The allowance levels are intended to cover individual variations among most normal persons as they live in the United States under usual environmental stresses. The recommended allowances can be attained with a variety of common foods, providing other nutrients for which human requirements have been less well defined. [3]Entries on lines for age range 22-35 years represents the reference man and woman at age 22. All other entries represent allowances for the midpoint of the specified age range. [4]The folacin allowances refer to dietary sources as determined by *Lactobacillus casei* assay. Pure forms of folacin may be effective in doses less than 1/4 of the RDA. [5]Niacin equivalents include dietary sources of the vitamin itself plus 1 mg equivalent for each 60 mg of dietary ryptophan. [6]Assumes protein equivalent to human milk. For proteins not 100% utilized factors should be increased proportionately.

TABLE 6: Recommended Daily Dietary Intake for a 70kg (154 lb) Man Compared with the Nutrients Supplied by One Quart of Milk

Nitrient	Average daily requirement for 70kg adult	Amount in 1 qt of milk	Approximate portion of daily requirement in 1 qt of milk (%)
Protein	56 (46 for 58kg woman)	34	61
Calories*	2,700	665	25
Calcium (g)	.8	1.2	150
Phosphorus (g)	.8	0.9	112
Iron (mg)	10.0 (18.0 for women)	2.0	20
Vitamin A (IU)	5,000	1,500†	30†
Vitamin D (IU)	400	25†	6†
Ascorbic acid (mg)	45	15	33‡
Thiamine (mg)	1.4	0.4	29
Nicotinic acid (mg)	18	0.8	4§
Riboflavin (mg)	1.6	1.5	94

*The calories in milk are divided equally between the fat and nonfat (skim milk) fractions:

		Milk Component	Grams/Quart	Calories/Quart		
Milk	Skim Milk	Protein	34	136	332	665
		Lactose	49	196		
		Fat	37	333		

†Milk is commonly enriched with 4,000 to 5,000 IU of vitamin A and 400 IU of vitamin D per quart.

‡Quantity in raw milk; pasteurization destroys about one-half of this ascorbic acid.

§Milk provides lactose which enables micro-organisms of the intestine to synthesize nicotinic acid.

Source: National Research Council, 1973.

TABLE 7: The Essential Amino Acids in a Pint of Milk Compared with the Average Minimal Daily Requirements for Adults[1]

Amino Acid	Content of One Pt of Milk[2] Gm	Minimal Daily Requirements[3] Gm/day	
		Men	Women
Isoleucine	1.09	0.70	0.45
Leucine	1.68	1.10	0.62
Lysine	1.33	0.80	0.50
Methionine + cystine	0.57	1.01	0.55
Phenylalanine + tyrosine	1.70	1.40	1.12
Threonine	0.78	0.50	0.31
Tryptophan	0.24	0.25	0.16
Valine	1.17	0.80	0.65

[1]Anon, (1965A)
[2]Amino Acid Content of Foods; Home Economics Res. Rept. *4*, U.S. Dept. Agr., Washington, D.C. Dec. 1957. Histidine not included as it is not a dietary essential for adults. Cystine and tyrosine qualify the need for methionine and phenylalanine respectively.
[3]Evaluation of Protein Nutrition: Committee on Amino Acids, Food and Nutrition Board, Natl. Acad. Sci. Natl. Res. Council, Publ. *711*, Washington, D.C. 1959

TABLE 8: Contribution of Dairy Foods to the Total Nutrients of the National Food Supply 1968[1]

Nutrients	Contributed by Dairy Foods, %
Food energy (calories)	13.3
Protein	22.6
Calcium	76.3
Carbohydrate (lactose)	7.2
Phosphorus	36.8
Iron	2.2
Vitamin A (plus carotene)	14.7
Vitamin D (90% or more of nation's fluid milk is fortified with Vitamin D)	
Vitamin B complex	
Riboflavin	43.1
Thiamine	9.9

[1]Anon. (1969A)

2.4 Contributions of Milk and Milk Products to World Supplies

Henderson (1971) reported the contribution of dairy foods to the total nutrients of the National Food Supply for 1968, as shown on Table 9.

TABLE 9: Total consumption of dairy products (per person per day 1976)

	Quantity	% of total	Woman hours
Protein	17.6 g	24.4	7.7
Fat	38.1 g	36.2	-
Carbohydrate	21.0 g	7.6	-
Calcium	621.0 mg	61.8	29.8
Thiamin	0.61 mg	14.2	4.3
Riboflavin	0.72 mg	40.6	13.3
Nicotinic acid equivalents	4.4 mg	15.5	7.0
Vitamin C	4.5 mg	9.4	3.6
Vitamin A (retinol equivalents)	336.0 µg	32.9	10.8
Vitamin D	495 kcals	21.7	5.4
Energy	(2.06 MJ)		

'The Recommended Daily Intake of Nutrients' - DHSS (1969).
Household Food Consumption and Expenditure (1976).

In the same manner, Smith (1969) stated that milk has a unique contribution to World Food Supplies, and in support of his statement, the following points are summarized:

(1) Milk and milk products are highly nutritious. They are excellent sources of vitamins and minerals, and their protein is not only of high biological value in itself but can greatly enhance the nutritive value of the protein as a whole. This complementary role of milk protein is fully recognized in many countries.

Table 10 shows the typical values for the percentage composition of cows' milk and for the same constituents in dried whole milk and dried skim milk (Smith, 1968).

TABLE 10: Typical Values for the Cow's Milk and Dried Whole Milk

	Milk %	Dried Whole Milk %	Dried Skim Milk %
Water	87.4	3	3
Fat	3.4	26	36
Lactose	3.6	28	1
Ash	4.8	37	51
Ca	0.8	6	9
P	0.10	0.8	1.1
Mg	0.01	0.1	0.1

(2) Milk is readily made into milk products with very little loss of nutritive value and these products can be packed, stored and used economically.

(3) The efficiency with which feedingstuffs are converted to milk depends in practice on many factors, but a point of outstanding importance is that, in making milk, ruminants can convert plant food unsuitable for man into palatable and nutritious human food.

2.5 Other Contributions of Milk to Man

In addition to offering consumers important food nutrients at low cost, there are many other significant aspects of milk and milk products (Campbell and Marshall, 1975). First, the pleasing palatability or taste of the milk and milk products. Secondly, milk is essentially of completely digestible - a desirable characteristic of all foods; additionally, there is no waste associated with the utilization of milk.

Many people have observed the relaxing effects of a cup of warm milk taken just prior to going to bed at night, and it is interesting to note that infants always sleep after consuming warm milk, when either breast-fed or bottle-fed. It is believed that the tranquilizing effect of milk is due to its high content of calcium. Calcium increases the force of the heartbeat and tends to dilate coronary arteries. Milk is valuable in the control of peptic ulcers. The clinically accepted principle of "no acid, no ulcer" still holds. Of special interest is the observation that the risks of stomach cancer decreases as milk consumption increases. In a recent study of 250,000 adult Japanese (Hirayama, 1968), it was found that the stomach cancer death rate per 100 was 28.8 for those who drank no milk, 22.5 for those drinking milk occasionally, and 13.0 for persons drinking milk daily.

CHAPTER III

CURRENT POSITION OF MILK SUPPLY IN SOME TROPICAL COUNTRIES

Protein is the basic nutritional shortage in our hungry world. According to the 1968 United Nations report "for over one'third of the present population in the developing countries the protein-calorie balance of the diet is inadequate". There is increasing evidence that malnutrition in early growth not only retards physical development but may also cause permanent retardation in mental development and learning ability.

Payne and Garcia (1968) stated that the dairy industry in the Philippines is a pioneer industry, growth has been slow and intermittent during the last decade, and the progress that has been made is mainly due to the dedication of a few individuals both within the government and the private sectors.

Milk consumption per capita in the tropical countries (Eusebio, 1967) is generally low. In most of these countries dairying is largely confined to the rural areas where the farmers possess small holdings and use their animals (1-4 head) for draft purposes and for the production of milk as well as meat. The milk produced is mostly from cattle and water buffaloes and, to some extent, from goats, sheep and camels (in Pakistan and Afghanistan).

3.1 World Position in Milk Production

According to McCabe (1955) the world produced only enough milk to meet 60 per cent of the world's population minimum dietary needs in 1953, but there were surpluses in some areas and shortages in others, as countries in the temperate zone containing 40 per cent of the world's population produced 85 per cent of the world's milk. The situation is probably very similar today.

In temperate countries there was an average of more than 220kg of milk per head available in 1953 while in tropical countries there was only about 30 kg as shown in Table 13. These local variations are often due to local dietary and agricultural customs (Payne, 1957) or to special political and social reasons, and are not necessary due to the inherent problems of milk production. Table 11 shows the estimated total milk production per capita in temperate and tropical climatic areas.

TABLE 11: Estimated total milk production and production per capita in temperate and tropical climatic areas (after McCabe[1])

Area*	Total milk production lb. x 10^6	Population x 10^6	Production per capita lb.
Temperate			
North America	138,067	174.9	789
South America	15,123	26.9	562
Western Europe	202,228	305.9	661
Eastern Europe	39,257	88.4	444
U.S.S.R.	57,235	205.0	278
Asia	6,220	126.8	49
New Zealand	11,748	2.0	5,874
Tropical			
Central America	1,080	9.4	115
Caribbean	2,201	16.9	130
South America	15,163	90.2	168
Africa	5,191	111.7	46
Asia (excluding India)	2,262	164.0	14
India†	42,360	367.0	115
Oceania (Islands)	145	2.7	54

*Data for Mexico, countries north of the tropics in Africa, the Middle East countries, Pakistan, China, Australia and certain minor territories have been excluded as these countries either have a sub-tropical climate or they are in both the temperate and tropical climatic zones.

†India has been included because, although part of the sub-continent has a sub-tropical, a major part has a tropical climate.

Dairy cattle are most prevalent in the cooler and relatively humid regions of the temperate zones (Schmidt and Van Vleck, 1974). About 80 per cent of the world's milk is produced in North America, Europe, the USSR, Oceania and South Africa.

Some countries, notably Ireland, Denmark and New Zealand have high per capita milk production; however, per capital consumption is considerably below production as shown in Table 12. Only 3 per cent of the total world's milk production crosses national boundaries. Northern Europe produces 71 per cent of this, with Netherlands, Denmark and France being the major suppliers.

TABLE 12: Countries that Led in Milk Production and in the per Capita Consumption of Milk, 1966.

Country	Fluid milk (lb)	Total in milk equivalent (lb)
Finland	631	1,514
Ireland	488	1,355
New Zealand	440	1,311
Denmark	387	972
Norway	537	968
Switzerland	403	924
Australia	306	924
Sweden	385	911
France	229	865
Belgium	235	862
United Kingdom	328	856
Canada	308	851
Netherlands	348	799
West Germany	209	759
Austria	339	715
United States	297	605
Italy	147	411

Source: National Milk Prod. Fed. 1968. *Dairy Producers Highlights.*

3.2 World Milking Animals

The world's cattle population is increasing more slowly than the world's human population (Williamson and Payne, 1978). One third of the world's cattle population is found in the tropics, 11, 14 and 11 per cent of the total in the continents of Africa, the Americas and Asia, respectively, as shown in Table 13. However, only 1 per cent is to be found in the tropical regions of Oceania.

TABLE 13: The World Milk Production, 1977 (Source: UN Statistical Yearbook, N.Y., 1978)

Country	Cow	Buffalo	Sheep	Goat	Total
		(thousand metric ton)			
World	394823	27092	6985	6606	435871
Africa	.65	.65	.11	.113	.195
N. America	69139	-	-	232	69371
S. America	33416	-	31	145	23582
Asia	23584	23587	2999	3221	59723
Europe	163775	85	3302	1457	118618
Oceania	980	-	-	-	-
USSR	88658	-	100	300	89058

3.3 Tropical position in milk production

Table 14 shows the cattle population of tropical countries exceeding 5 million.

Cattle produce 92 per cent of the world milk supply (Folley *et al.*, 1975), water buffaloes 5 per cent, goats 3 per cent and sheep 2 per cent. Small quantities of milk for human consumption are also obtained from camels, donkeys, mares, reindeer and yaks.

In very general way it may be concluded that the major concentrations of cattle are found insome of the intensive subsistence agricultural regions and in natural grasslands (Williamson and Payne, 1978), and there are relatively few cattle in some of the very dry regions and in some of the humid rain-forest regions of the equatorial zone.

TABLE 14: Tropical countries with a cattle population exceeding 5 million

Continent	Country	Cattle population ((million)
Africa	Ethiopia	26.5
	Kenya	7.4
	Madagascar	9.5
	Nigeria	10.9
	Sudan	15.2
	Tanzania	11.3
Americas	Brazil	85.0
	Colombia	22.1
	Cuba	7.4
	Mexico (tropical regions)	13.3
	Paraguay*	6.0
	Venezuela	8.7
Asia	Bangladesh (tropical regions)	13.0
	Burma	7.7
	India (tropical regions)	88.5
	Indonesia	6.3
Oceania	Australia (tropical regions)	7.3

* Paraguay is considered to be wholly in the tropics for the purpose of these estimates

Source: FAO (1974)

3.4 Philippine position in milk production

Various estimates have been made of the number of milking cows and buffaloes in commercial herds, and the available data has been assembled in Table 15 (Payne and Garcia, 1968) together with a projection of the number that might have been milked in 1975.

TABLE 15: Estimated number of milking carabao and cattle in commercial herds

Year	Carabao and buffalo	Cattle Indigenous	Exotic	Total
*1950	9,505	2,180	174	2,354
*1955	14,300	3,280	257	3,537
**1959	16,732	3,390	750	4,140
*1963	25,000	6,000	2,000	8,000
**1965	27,340	8,320	2,230	10,550
**1975	36,740	11,235	4,500	15,735

* First National City Bank (1960) **U.S. Dept. Agric. (1964)

The estimated number of milking cattle and buffalo in commercially exploited herds during the years, 1950, 1955 and 1963 is shown in Table 16. The percentage of the national cattle herd that is milked is very low (Payne, 1968), being less than one, but it doubled between 1950 and 1963 and the number of the exotic cattle milked increased during the same period.

TABLE 16: Estimated number of milking animals in commercially exploited herds

	1950		1955		1963	
	Est. No.	% Total Pop.	Est. No.	% Total Pop.	Est. No.	% Total Pop.
Cattle						
Native and crosses	2,180	0.29	3,280	0.41	6,000	0.50
Exotic	174	0.02	357	0.03	2,000	0.17
Total	2,354	0.31	3,537	0.44	8,000	0.67
Buffalo*	9,503	0.32	14,300	0.44	25,000	0.78

* Includes carabao, Murrah buffalo and crosses between carabao and Murrah

Projections of the numbers of milking cattle and buffalo in commercially exploited herds for 1965/75 are shown in Table 17. In these projections, it was assumed that the same proportions of adult female native and crossbred cattle and carabao were as milked in 1963 but the number of exotic cattle would have increased at the rate of 9 per cent per annum.

TABLE 17: Projected number of milking animals in commercially exploited herds 1965 and 1975

Cattle	1965	1975
Native and crosses	8,320	11,235
Exotic	2,230	4,500
Total	10,550	15,735
Carabao and buffalo	27,340	36,740

3.5 Milk importations of the Philippines

Estimates of local milk production and details of imports are shown in Table 18 (Payne and Garcia, 1968). Imports represented 29.5 per cent of the total of all food imports in 1966 and cost ₱136,356,171.00 so that there would be a considerable and worthwhile saving in foreign exchange if a higher proportion could be produced locally.

TABLE 18: Estimates of local production of liquid milk and details of importation of milk and milk products (1955-1965)

Year	Estimated local* production x 1,000 kg	Imports of milk and milk products Quantity x 1,000 kg	Value ₱
1955	6,366	88,338	54,367,136
1959	8,442	64,595	36,126,238
1963	15,265	68,198	77,940,797
1965	17,491	78,366	111,732,443

*This includes the milk of carabao, buffalo and cattle but not goats.
Sources: Bureau of Agricultural Economics and Bureau of Census and Statistics, Manila.

Similarly, the cost of the total importation of milk and milk products and beef is shown in Table 19 (Payne and Garcia, 1968).

Estimates of the domestic production of milk and imports of milk are shown in Table 22, imports of milk, milk products and beef for the period 1960-1962 are shown in Table 20 and Table 21. It will be seen that the production of commercial whole milk in the Philippines was less than 3 per cent of the total consumption demand in the period 1960-1962, approximately 4 per cent in 1968 (Payne, 1968) and probably little higher than this in 1979.

TABLE 19: The cost of imports of milk, milk products and beef expressed in absolute terms and as a percentage of the cost of total food imports, 1956-66

	1956 x 1000 ₱	1959 x 1000 ₱	1963 x 1000 ₱	1966 x 1000 ₱
Milk and milk products	56,422	36,126	77,941	116,152
Beef	14,467	11,360	17,888	20,204
Total	70,889	47,486	95,829	136,356
As % of total food imports	40.4	40.6	29.8	29.5

Source: Bureau of Census and Statistics, Manila

TABLE 20: Estimated domestic production and imports of milk 1960-62 (x 1,000 kg)

	1960		1961		1962	
	Est. Prod.	% Total	Est. Prod.	% Total	Est. Prod.	% Total
Domestic						
*(1) Whole milk; commercial production	10.7	2.7	10.8	2.7	11.2	2.6
(2) Whole milk; non-commercial production	232.2	57.5	228.9	56.4	241.8	56.4
**(3) Filled milk	101.0	25.0	115.0	28.3	128.0	29.8
Imports	60.0	14.8	51.3	12.6	48.0	11.2
Excluding dry skim milk powder						
Total	404.0		406.0		429.0	

* This includes cattle, buffalo and goat milk production.

** This filled milk industry utilises skim milk powder and locally produced coconut and corn oil.

TABLE 21: Imports of milk, milk products and beef expressed in absolute terms and as a percentage of the total cost of food imports, 1960-62. (x 1,000 pesos)

	1960		1961		1962	
	Cost	As % Total	Cost	As % Total	Cost	As % Total
Milk and milk products	47,475	14.2	48,045	12.1	90,399	26.5
Beef	11,824	3.6	8,034	2.0	28,458	8.3
Total	59,299	17.8	56,079	14.1	118,857	34.8
Total	333,941		397,185		341,898	

3.6 Utilization of milk in the Philippines

STudies on the utilization of milk produced locally in the Phillipines revealed that 50 per cent of the carabao milk produced was consumed on the farm (Payne and Garcia, 1968), and almost one-third was used for the manufacture of either cheese (cooked) or soft cooked cheese. It has also been shown that approximately 90 per cent of locally-produced cow's milk is sold on the liquid milk market and 10 per cent is used in the manufacture of ice cream as shown in Table 22.

TABLE 22: Utilization of milk produced localled

	As % total production of raw milk	
	Carabao and buffalo	Cattle
Cottage cheese (Keso)	27.5	-
Milk sweets (Pastillas de leche)	10.0	-
Ice-cream	3.0	10
Fresh milk	59.5	90
Bottled	9.5	90
Home consumption	50.0	-

Source: U.S. Dept. Agric. (1964)

The major processing units for the production of milk products is shown in Table 23. The total output of these plant is approximately 250,000 metric tons per annum of fresh milk equivalent of which approximately 100,000 metric tons are filled milk (Payne and Garcia, 1968).

TABLE 23: Major Processing Units in the Philippines

Date of establishment	Company	Product
1957	Darigold Milk Co., Paranaque, Rizal	Evaporated filled milk
1957	General Milk Co. (Philippines) Mandaluyong, Rizal	Evaporated filled and recombined milk
1960	Milk Industries Inc., Marikina, Rizal	Evaporated filled and recombined milk
1964	Wyeth-Suaco Laboratories, Makati, Rizal	Special milks
1965	Nutritional Products, Alabang, Rizal	Special milks

There are also some other processing plants in the Manila area as shown in Table 24 (Payne and Garcia, 1968).

TABLE 24: Other Processing Units in Manila, Philippines

Company	Products
Magnolia Milk and Milk Products Plant, Manila	Pasteurized fresh milk chocolate milk, reconstituted milk, skim milk, buttermilk, yoghurt, ice-cream, sherbert, cheese spread and cottage cheese, etc.
Selecta, Quezon City	Pasteurized carabao milk and ice-cream.
International Nutrition Products, Makati	Soybean milk.
Pacosta Dairy Products, Inc. Quezon City	Filled and recombined milk in bottles, processed cheese and reconstituted ice-cream.
New Zealand Creamery Inc. Makati, Rizal	Reconstituted butter, cheese.
Silver Bell Ice-Cream Co., Quezon	Ice cream, etc.

3.7 Animal products per capita

The intake of animal products in the diet of the average Filipino ranks among the lowest (Loosli, 1969) as shown in Table 25. The low total protein intake, as shown in the table, is cause for concern.

TABLE 25: Animal products consumed per capita

Area	Milk	Meat	Eggs	Fish	Protein Animal	Protein Total
			g/day			
North America	850	248	55	26	66	93
Oceania	574	312	31	22	62	94
Europe	494	111	23	38	36	88
Latin America	204	67	9	20	19	61
Far East	51	24	3	27	8	56
Near East	214	35	5	12	14	76
Africa	96	40	4	16	11	61
Philippines	38	52	7	32	9	50

3.8 Data on calories and proteins in selected countries

The availability of calories and protein per capita per day in selected countries is shown in Table 26. Milk provides a significant portion of the animal protein consumed in the U.S. and Canada, in most of the European countries, and in New ZEaland, Australia and Uruguay (Schmidt and Van Vleck, 1974).

There is no shortage of animal protein in the world as a whole, but in many developing countries the availability is at low levels per person per day - in the Philippines, only 19.7g per head daily.

TABLE 26: Availability of Calories (in Descending Order) and Protein in Selected Countries

Country	Calories	Total protein (grams)	Animal protein (grams)	Milk protein (grams)
AFRICA				
Union of South Africa	2,820	80.2	31.5	7.9
United Arab Republic	2,810	80.8	11.8	4.3
Libya	2,660	63.7	14.7	4.6
Mozambique	2,420	47.9	3.8	0.2
Madagascar	2,330	52.3	9.4	0.8
Ivory Coast	2,290	52.3	10.3	0.5
Nigeria	2,180	59.3	5.3	0.6
Ghana	2,160	48.6	10.5	0.3
Kenya	2,120	64.4	12.1	3.4
Mali	2.120	64.2	10.9	0.3
Tanzania	2,080	58.1	9.1	1.4
Uganda	2,070	50.1	10.2	2.2
Morocco	2,060	54.3	9.7	0.3
Ethiopia	2,040	54.4	10.0	8.4
Sudan	1,940	63.9	25.9	12.3
Algeria	1,870	51.7	6.4	2.0
Tunisia	1,840	52.2	10.8	3.6
Somalia	1,780	51.6	16.3	7.4
ASIA				
Turkey	3,110	97.5	15.9	7.7
Israel	2,920	89.2	41.3	13.1
Lebanon	2,800	80.8	28.3	12.4
Syria	2,600	77.9	10.3	4.2
Taiwan	2,520	68.2	23.9	0.5
Japan	2,460	74.7	28.2	4.1
Malaysia	2,400	54.3	16.3	3.9
South Korea	2,390	70.5	11.5	0.2
Pakistan	2,230	51.5	11.2	9.8
Jordan	2,190	54.9	13.6	4.8
Ceylon	2,170	48.0	8.3	1.9
Iraq	2,100	60.7	16.8	7.2
Philippines	2,000	50.5	18.7	1.9
Indonesia	1,980	38.2	4.5	0.1
Afghanistan	1,950	56.4	7.7	3.1
Iran	1,890	49.8	11.5	5.0
Saudi Arabia	1,850	50.9	12.1	3.5
India	1,810	45.4	5.4	5.2
EUROPE				
Ireland	3,460	94.1	59.9	26.4
Poland	3,350	92.9	37.6	18.1
Yugoslavia	3,190	92.8	21.3	10.4
Switzerland	3,170	88.0	52.8	23.1
Romania	3,160	97.3	27.9	12.3
United Kingdom	3,150	87.5	53.8	21.0
Denmark	3,150	88.7	60.2	24.5
Hungary	3,140	96.4	39.4	10.1

TABLE 26: cntd

Country	Calories	Total protein (grams)	Animal protein (grams)	Milk protein (grams)
France	3,100	100.7	59.9	21.2
Belgium-Luxembourg	3,090	87.5	50.6	18.7
Netherlands	3,080	84.6	53.6	24.3
West Germany	2,960	80.9	52.0	19.5
Norway	2,950	81.2	50.4	24.3
Austria	2,920	85.6	49.5	19.4
Greece	2,900	98.9	43.0	15.7
Finland	2,890	87.2	55.8	32.7
Italy	2,860	85.4	35.5	14.6
Sweden	2,850	79.8	54.1	24.7
Spain	2,790	81.9	34.8	11.3
Portugal	2,770	83.0	31.7	5.3
NORTH AMERICA				
United States	3,200	95.6	68.6	23.3
Canada	3,180	95.4	64.1	22.3
Costa Rica	2,610	57.9	21.8	9.3
Mexico	2,550	65.7	15.2	5.5
Panama	2,500	62.9	23.9	4.8
Nicaragua	2,350	59.0	20.1	10.4
Dominican Republic	2,290	41.7	15.3	6.4
Jamaica	2,260	52.6	18.7	6.1
Guatemala	2,220	56.8	8.3	2.3
Honduras	2,010	51.0	14.5	8.7
El Salvador	1,840	44.2	9.4	4.7
OCEANIA				
New Zealand	3,290	107.3	74.3	26.7
Australia	3,120	90.5	60.6	21.6
SOUTH AMERICA				
Uruguay	3,170	101.6	67.1	20.4
Argentina	2,920	88.0	58.7	11.8
Chile	2,830	81.8	27.1	9.6
Brazil	2,690	66.3	18.3	5.1
Paraguay	2,520	63.3	23.7	6.2
Venezuela	2,490	65.9	26.4	7.1
Peru	2,340	54.1	19.9	5.7
Colombia	2,200	48.9	22.6	9.8
Ecuador	2,020	51.5	17.9	6.7
Bolivia	1,980	50.6	13.2	2.7

Source: FAO production yearbook, 1967.

CHAPTER IV

DIRECT EFFECT OF CLIMATE TO DAIRY ANIMALS

In most humid tropical countries (Payne and Laing, 1962) the cattle are stunted, growth is slow, sexual maturity is delayed and milk production is low by temperate zone standards. This low productivity can be attributed to a complex of factors including the lack of improved indigenous breeds, faulty nutrition and management, and lack of control of diseases and parasites. Furthermore, the growth-inhibiting effects of extremely high and low temperature are well recognised (Winchester, 1964).

There are profound differences between species (Findlay, 1954), between breeds within a species (Worstell and Brody, 1953), and between individual animals within a breed (Payne and Hancock, 1957) in ability to withstand the direct effects of climate, particularly heat stress. The normal reactions of cattle under heat stress is to limit feed intake and increase water intake. These facts have been demonstrated clearly by experimental work using climatic chambers, notably by workers at Missouri and Louisiana in the United States, and also by using the results of many field studies.

4.1 Critical temperature of cattle

Ambient temperature is known to affect the rate of metabolic heat production (Meltzer, 1973). The lower critical temperatures in the dairy cow have been estimated from calometric studies and are 20°C at maintenance, -4°C when producing 10 kg fat-corrected-milk (FCM), and -10°C when producing 20 kg fat-corrected-milk (Hamada, 1971). Similar figures have been obtained from calorimetric studies in steers (Baxter and Wainman, 1961). These are estimates of the temperature at which the animals produce the least thermal stress while peripheral heat loss is minimized by vasoconstriction. These temperatures are very low, however, when compared with the actual temperatures at which the animals produce large milk yields; 21°C in the Betsville experiments (Moe *et al.*, 1972), and the markedly higher mean summer temperature in the hot desert area in the South of Israel (Kali *et al.*, 1970). These critical temperatures imply a very wide thermoneutral zone, about 30 to 40°C wide.

The thickness of coat can prevent the entry of heat into the animal body. Hayman and Nay (1961) stated that hair coat type is shorter in *Bos indicus* and thereby they have less dense coats than *Bos taurus*. In regard to the coat colours, cream to light brown seem to be the ideal because of little absorption of heat into the animal body. Reimerschmid and Elder (1945) concluded that the emissisities of different coloured coats to solar radiation ranged from 0.49 for white Zebu cattle to 0.89 for Black Aberdeen Angus. Hutchinson and Brown (1969) further stated that the higher emissivities absorb more solar radiation at or close to the surface of the coat but the extent to which this influences heat tolerance is uncertain (Schleger, 1962). With regard to the upper critical temperature, it is commonly known that the high-producing animal has a higher heat production than the animal at maintenance which means its heat tolerance is much lower. The upper limits for optimal production of dairy cows is probably somewhere 20°C and 25°C for *Bos taurus* and 30 to 35°C for *Bos indicus* (Bianca, 1965). Table 27 shows the best heat production of cattle confined at thermoneutrality and at different stages of production.

TABLE 27: Heat production of cattle confined at thermoneutrality and at different stages of production

	Body weight (kg)	Surface area (m^2)	Heat production $MJ\ day^{-1}$	W	$MJ\ m^{-2}\ day^{-1}$	$W\ m^{-2}$
Fasting metabolism						
Calf 1 month old	50	1.24	9.43	109	7.6	88
1 year old	300	4.11	33.2	384	8.1	93
Steer 2 years old	450	5.39	34.7	401	6.4	74
Growing cattle						
Veal calf 1.5 kg gain/day	100	1.97	26.3	304	13.3	154
Baby beef 1.0 kg gain/day	150	2.58	31.0	359	12.0	139
	350	4.55	56.7	656	12.5	144
1.3 kg gain/day	150	2.58	33.5	387	13.0	150
	350	4.55	61.1	707	13.4	155
Store cattle maintenance	250	3.64	38.7	448	10.6	123
0.4 kg gain/day	250	3.64	49.8	576	13.7	158
Fat stock 0.8 kg gain/day	450	5.39	73.0	845	13.5	157
1.5 kg gain/day	450	5.39	81.5	943	15.1	175
Beef cow maintenance	450	5.39	50.0	578	9.3	107
Dairy cattle						
Dry, pregnant	500	5.79	52.2	604	9.0	104
2 gallons/day	500	5.79	64.6	747	11.1	129
5 gallons/day	500	5.79	77.0	891	13.3	154
8 gallons/day	500	5.79	89.4	1034	15.4	178

The loss of heat (Meltzer, 1973) determines the energy requirement for maintenance of homeothermy. Metabolic heat production is regulated to this required rate by the body temperature control. Table 28 shows the input and output of heat produced in cow's body.

TABLE 28: Input and Output of Heat in Cow's Body

	Cow's body	
Solar Radiation	Heat production from feed and body reserves	Radiation Conduction Convection Evaporation
Conduction		
	Heat of maintenance Heat of increased metabolism due to production lactation pregnancy etc.	
Feed Water	Heat of activity Heat of fermentation in the rumen	Faeces Urine Milk

The thermoneutrality effect is bounded at the colder limit by rising metabolic rate (Mount, 1974), and at the warmer limit by incurred evaporative loss. Webster (1974) stated that when ambient temperature is below skin temperature, wind has a cooling effect.

The efficiency of evaporative loss depends on vapour pressure in the moist surface of the skin, the respiratory tract and the air contact with them. Variations in relative humidity between 35% and 75% have little effect on the rate of evaporation of sweat from the skin (McLean, 1963; McLean and Calvert, 1972). These workers concluded that the rate of active secretion of sweat was uninfluenced by relative humidity until vapour pressure approached saturation point. Cattle at 35°C have respiration rates of about 100 and 16 per minute at relative humidity of 35% and 75%, respectively (McLean and Calvert, 1972). Increasing the required humidity clearly increases the physiological work required for thermal panting. Turner and Schleger (1960) stated that *Bos indicus* cattle do have an increased capacity to sweat and, moreover, their finer skin and glossy coat enhance evaporation.

4.2 <u>Effect of Climate on Milk Yield and Milk Composition</u>

Experimental evidence on the effect of climate on milk butterfat and solids-not-fat production has been reviewed by Findlay (1954). Most of the available data indicates that milk, milk fat and solids-not-fat production are depressed by high ambient temperature, but, as in growth studies, it is difficult to disentangle the direct and indirect effects of climate (Williamson and Payne, 1978). Payne and Hancock (1957), working with identical twin Jersey,s noted that climate had a marked effect on milk and milkfat but not on solids-not-fat production. The average milk production of the twins in a temperate climate was 44% higher than that of their pairmates in the tropics, and their milkfat production was 56% higher. The optimal temperature for milk production in temperate-type cattle breeds appears to be 10^{o}C, while the critical temperature after which milk production steeply declines is 21^{o}C to 27^{o}C in Jersey and Holstein, 29^{o}C to 32^{o}C in Brown Swiss, and higher in the case of tropical-type cattle (Williamson and Payne, 1978). The milkfat content of the milk in the case of tropical-type cattle declines slowly until the ambient temperature reaches 29^{o}C, and then rises. High ambient temperatures also affect other constituents of milk in temperate-type milking cattle (Williamson and Payne, 1978). Cobble and Herman (1951) have shown that there is a rise in chloride content and a fall in the lactose and total nitrogen content of milk when ambient temperatures rise about 27 to 32^{o}C.

Generally the yield and composition of milk are much the same (Johnson, 1965) within a temperature range of 0 to 21^{o}C. From 21^{o}C to 27^{o}C the yield decreases slowly and the fat percentage is reduced but beyond 27^{o}C the decline in yield is much more marked whereas the fat percentage increases and the content of solids-not-fat is usually decreased. Branton *et al.*, (1975) reported that season of calving had important effects affecting peak milk yield of Holstein cows at Louisiana, U.S.A.

4.3 Effect of Climate on Cattle Growth

If climatic stress depresses appetite, reducing the feed intake and grazing time, then it is likely to affect productivity as measured by both growth and milk production (Williamson and

Payne, 1978). Hancock and Payne (1955) noted in Fiji that the belly girth of twin Jersey heifers was adversely affected and this was attributed to the fact that they had much greater water intake. Results also suggest that an oceanic tropical climate does not appreciably affect the growing rate of temperate-type cattle if management and feeding conditions are good. The birthweight of most *Bos indicus* calves is low and they often grow rather slowly, but what part if any of this poor growth can be attributed to the effect of climate is unknown.

Previous work showing a reduced bodyweight in a hot environment has underestimated the retardation in growth because there is an increase in body water which partly hides the real loss of body solids (Kamal and Johnson, 1971).

4.4 Effect of Climate on Lactation

Before 1965 there were many research studies reviewed by Bianca (1965) and Hafez (1968) on the effect of a hot climate on lactation. It has been shown that heat stress reduces milk yield (Thompson, 1973). The temperature at which this occurs varies with different breeds. The fall in milk yield and food intake due to high temperature and humidity is more marked in mid-lactation (100-180 days) than at other stages (Maust *et al.*, 1972).

4.5 Effect of Climate on Nutrition

At the thermoneutral temperatures, voluntary food intake does not vary with temperature, but at higher temperatures it is reduced, and at lower temperatures it is increased (Thompson, 1973). In hot environments, a ration high in protein content and low in fibre content is beneficial for keeping down body temperatures and improving production. Johnson *et al.*, (1966) concluded that a decline in feed intake is a major factor in the decline in lactation due to heat, but high body temperatures or environmental heat are still considered to be direct causes of some of the losses in production. The crude fibre content of humid tropical forage is not only inversely related to the amount of rainfall, but appears to be consistently higher than that of tmperate forage at the same stage of growth (French, 1959). This is an additional disadvantage to animals that are already under heat stress and finding difficulty in eating a sufficient bulk of watery forage.

4.5.1 Feed intake

Generally, the effect of high ambient temperature is to depress the feed intake of all types of cattle, but the feed intake of *Bos taurus* is depressed at lower temperature than in *Bos indicus* breeds (Worstell and Brody, 1953; Johnson *et al.*, 1958; Johnson *et al.*, 1960; Johnston *et al.*, 1961; Allen, 1963; Randel and Ruseff, 1963).

4.5.1.1 Effect of ambient temperature

The effect of very high ambient temperatures on feed intake is very pronounced. Ragsdale *et al.*, (1948) showed that the feed consumption of Holstein and Jersey cattle virtually stopped when ambient temperature rose to 40.6^{o}C, and Robinson and Kelmm (1953) stated that rumination of Illawarra Shorthorns ceased at body temperatures above 40^{o}C. More recently, Allen (1963) concluded that in a hot dry environment, 28^{o} to 44^{o}C, the contraction of smooth muscle in all parts of the digestive tract of buffaloes became weak and infrequent and that the passage of digesta was very much depressed. Johnson *et al.*, (1961) further concluded that at 25^{o}C the feed intake decreased more than the milk production did, and that bodyweight was lost.

4.5.1.2 Effect of humidity

This aspect has been studied in Missouri, where Ragsdale *et al.*, (1953) reported that increasing humidity at ambient temperatures above 24°C depressed the feed intake of Holstein, Jersey, Brown Swiss and Brahman cattle, while Johnson *et al.*, (1963) have shown that when lactating Holsteins are kept at ambient temperature of 32°C, feed intake is normal when relative humidity was 20 per cent, but when humidity rose to 40 per cent, there was severe depression in both dry matter intake and total digestible nutrient intake.

4.5.1.3 Effect of radiation

Brody *et al.*, (1954) studied the effect of radiation on the feed intake of lactating Holsteins and Jerseys, and non-lactating Brahman cattle and found that when animals are exposed to radiant energy from incandescent and fluorescent lamps while the ambient temperature was 21.1 to 26.9°C, the total digestible nutrient intake of Holsteins declined more than that of the Jerseys, and that the intake of Brahmans was unaffected.

4.5.2 Water intake

The direct effect of climate on water intake of ruminants is very complex, as water is required for at least two different purposes - first, as an essential nutrient and component of the body, and second, in assisting the animal to lose heat by conductive and evaporative cooling. The total water intake of species, breeds within breeds, and individuals within a breed varies very wide limits, but all domestic animals usually require access to free water. The effect of the climatic environment on the water demand of ruminants varies according to their basic water requirements which may change with age, size and productivity.

4.5.2.1 Effect of ambient temperature

Winchester and Morris (1959) found that between -12.2 and 4.4°C, the rate of water intake per unit DM consumed remained relatively constant, while above 4.4°C it increased with increasing ambient temperature at an accelerating rate. However, the relationship between water intake and ambient temperature is not simple. Reagan and Mead (1939), Ragsdale *et al.*, (1949) and Ragsdale *et al.*, (1951) have shown that the water consumption of Holstein, Brown Swiss and Jersey milking cows rose as temperature increased from 4.4 to 26.7°C, but that above 29.4° it declined. When non-milking animals were studied, a decline in water intake did not occur until the ambient temperature further increased (Ragsdale *et al.*, 1951). It has been suggested that the decline in water intake above a certain ambient temperature can be attributed to a decline in feed intake and production, and to a rise in body temperature (Winchester, 1964).

Ambient temperature has a differential effect on the water intake of the different breeds of cattle (Johnson *et al.*, 1958; Johnson and Yeck, 1964) and it appears that acclimatized animals require less water than unacclimatized when they are managed at a high ambient temperature.

4.5.2.2 Effect of humidity

Harbin *et al.*, (1958) demonstrated that there was no relationship between relative humidity and water intake if ambient temperature remained constant, but, if the latter altered, water intake was affected by humidity. Ragsdale *et al.*, (1953) found that at ambient temperatures above 23.9°C, increasing humidity decreased water consumption, while the frequency of drinking increased. This may, of course, simply reflect decreases in the ability of the animal to utilize water for evaporative cooling purposes. Johnson *et al.*, (1963) studied the effect of increased humidity on water intake at different ambient temperatures and concluded that the effect was very variable.

4.5.2.3 Effect of radiation

According to Brody *et al.*, (1954) the effect of increased radiation intensity on lactating Holstein and Jersey and non-lactating Brahman cattle is to increase the water consumption. Presumably this is due to the animal utilizing increasing amounts of water for evaporative cooling purposes, when subjected to increased radiation stress.

Water intake in the field depends on many factors but the experimental evidence suggests that, in the case of most domestic ruminants, there is a direct relationship between climate stress and water intake (Mullick *et al.*, 1952; Payne and Hancock, 1957; Harbin *et al.*, 1958; Macfarlane, 1958; Pagot and Delaine, 1958).

4.5.3 Efficiency of utilization of nutrients

If climate can affect the level of nutrient intake, body temperature, respiration and pulse rates, and thus the general metabolic function of ruminants, it may also affect efficiency of utilization of feed (Payne, 1969). Experimental evidence on the overall effect of climatic environment on efficiency of utilization is limited, but what there is suggests that, under controlled conditions, increasing ambient temperatures decreases efficiency, though under field conditions, the difference may be insignificant (Hancock and Payne, 1955; Payne and Hancock, 1957;

Armstrong *et al.*, (1958); Wayman *et al.*, 1952). Wayman *et al.*, (1962) concluded that high ambient temperature cause a significant decrease in efficiency of energy utilization for milk production and suggest that that is due to a decrease in the rate of passage of feed through the intestinal tract.

4.5.3.1 Digestibility

Graham *et al.*, (1959) showed that digestibility was inversely related to the plane of nutrition in ruminants subjected to controlled climatic conditions. It might be expected that as ambient temperature rise and feed intake declines, digestibility of ingested feed would increase. However, the experimental evidence is contradictory (Johnson *et al.*, 1958) Johnson *et al.*, 1960; Davis and Merilam, 1960; Blaxter and Wainman, 1964; Kofb and Pfander, 1965). Vercoe and Fresce (1972) shows that increase of rectal temperature of 26.8^{O}C by 1.4^{O}C caused a decrease in food intake in all breeds. This is probably due, however, to a capacity to evaporate moisture despite a small increase in DM digestibility associated with a rise in rectal temperature.

4.5.3.2 Concentration of V.F.A. into Rumen

It has been recognized for some time that the heat increment of feeding in ruminants is related to acetic acid production in the rumen (Armstrong and Blaxter, 1957; Armstrong *et al.*, 1957; Armstrong *et al.*, 1958). More recently, Weldy *et al.*, (1962) and Weldy *et al.*, (1964) have shown that high ambient temperatures cause an insignificant decrease in the concentration of rumen VFA but a significant decline in the acetate:propionate ratio, and in one experiment the VFA concentration was significantly correlated with rectal temperature. On the other hand, Kelly *et al.*, (1965), who maintained non-lactating cows at 1.6^{O}F at 50 per cent relative humidity on a constant feed intake, have demonstrated a marked decline in acetic, propionic and total VFA from values of 9.99, 3.76 and 15.31 to 4.67, 1.06 and 6.63 m-equiv./100ml at 1.6° and 37.7°C, respectively.

4.5.4.3 Loss of Nutrients by Sweating and Drooling

Cattle sweat glands are present in some number and are functional (Ferguson and Dowling, 1955), though some types of cattle possess more glands per unit area of skin than others (Dowling, 1955), and the volume of sweat glands appears to be more important than the number per unit area of the skin (Pan, 1963).

Sweating behaviour as ambient temperature rises, also differs between cattle types (Allen, 1962; Banerjee *et al.*, 1964). Banerjee *et al.*, (1964) showed that the sweating rate of Holstein heifers increased rapidly with increase in ambient tmperature, and that at 35°C the rate was 210 g per sq.m. per hour. There was a significant positive correlation between sweating rate and the number of sweat glands per unit area of skin. The authors concluded that the acclimatized cattle sweat more profusely than do acclimatized animals. According to Bonsma (1940) losses of saliva and minerals in cattle through drooling can amount to 18.1 and 50 to 89 g per day, respectively.

4.6 Effect of Climate on Reproduction

Heat and cold can cause a decline in reproductive efficiency in both males and females through decreased gametogenesis, libido, oestrus, ovulation, fertilization, implantation, embryo survival, gestation length, abortions, still births and mothering ability. The extent of effects of thermal stress on reproductive failure depends on species and breed, acclimatization nyethermal fluctuations occurring in daily temperature are referred to as nycthermal fluctuations.

In cows, heat stress delays puberty causes anoestrus, depresses oestrual activity, lowers conception rates, induces abortions and increases perinatal mortality. In heat stressed cows, adrenal and ovarian functions are depressed and the higher levels of circulating corticosteroids and progestin correspond with poor reproductive performance. Cooling cows will decrease plasma hormone levels and increase reproductive efficiency (Higher, 1979).

Branton (1970) concluded that high environmental temperature can directly affect the reproductive performance of cattle and that high humidities reinforce the effect of high temperature. Table 29 shows the known effects of climatic stress on the reproductive behaviour of cattle.

TABLE 29: Known Effects of Climatic Stress on the Reproductive Behaviour of Cattle

Female cattle	Male Cattle
Age of puberty	Age at puberty
Regularity and duration of the oestrus cycle	Sexual libido
Incidence of abnormalities of the ova	Interference with the thermoregulatory function of the scrotum affecting spermatogenesis and semencharacteristics
Embryonic mortality	
Foetal death rate	
Gestation length	
Foetal size	

Known effects of climatic stress on the reproductive behaviour of cattle

4.7 Effect of Climate on the Grazing Behaviour of Cattle

The effect of climate on cattle is reflected in their grazing behaviour (Williamson and Payne, 1978). The length of daytime grazing of cattle apparently varies according to the degree of climatic stress, the breed type of cattle utilized and the quantity and quality of the pasture available.

4.8 Effect of Climate on the Cardiovascular System and the Endocrine System

Bianca (1966) has reviewed the evidence that in cattle exposed to moderate heat, the heart rate may vary, depending on metabolic rate. In the hyperthermic animal there is an increase in blood pressure and heart rate and no consistent effect on cardiac output. Recent experiments have shown that in moderate heat there is an increase in cardiac output and central body volume, while the total peripheral vasodilation (Whittow, 1971). In steers which have become hyperthermic due to severe heat stress, there is an increase in heart rate which can be attributed to the Van Hoff-Arrhenuis effect (Whittow, 1971).

An injection of growth hormone increases the heat production of animals and simultaneously increases the thyroxine disppearance rate. It is suggested that growth hormone and thyroxine have a synergistic effect on metabolic rate (Yousef and Johanson, 1966), although growth hormone has a shorter laten time before having its effect. After 3 weeks at a high environmental temperature, cows have a reduced plasma growth hormone concentration, which is partly a dilution effect because of the growth hormone distribution space in the body increases. There is also a fall in growth hormone secretion rate and a slower hormone disappearance rate (Mitra *et al.*, 1972).

4.9 Environmental Factors Influencing Physiological Functions and Growth

4.9.1 Ambient temperature

Environmental temperature has been shown to influence food and water intake, availability of energy in ingested food, heat production of animals, net energy available for productive purposes and body composition of growing animals.

4.9.2 Available energy, heat production and net energy

Winchester and Morris (1979) have pointed out that feed intake declines with increasing ambient temperature.

4.9.3 Wetting

A number of workers have reported that weight gains of animals during hot weather have been increased by wetting (Winchester, 1964).

4.9.4 Humidity

Ragsdale *et al.*, (1953) concluded that as the humidity increases, milk yield decreases and the gain allowances which were based on milk yield, as consequences were lower; therefore, the relationship between rising humidity and decreasing energy intake appears to be complex.

4.9.5 Cattle can withstand remarkably low levels of ambient temperature in combination with relatively rapid air movement. However, wind can be very harmful to exposed cattle at low temperature if the animals are wet (Winchester, 1964).

4.9.6 Radiation

The influence of sunlight and ultra-violet radiation are among the most dramatic of biological phenomena and, perhaps among the least understood at the present time.

4.9.7 Length of Day

Some effects of changing length of exposure to sunlight on migration season and on reproductive processes in plants and animals are well known (Winchester, 1964); for example, the increasing sex activity of sheep and goats with decreasing length of day.

4.10 Economic losses

Wiersma and Stott (1966) enumerated the economic losses resulting from heat stress, to wit:

4.10.1 Economic losses due to low breeeing efficiency

(a) inconvenience and costs of repeated inseminations

(b) prolonged lactations or dry periods due to low breeding efficiency resulting in long maintenance periods without profit from production.

(c) cost of replacing cows sold for slaughter because of their delay in settling; the resultant prolonged lactation makes it impossible for them to continue producing at a profitable level.

(d) the inability to breed dairy cows so that they will calve during appropriate seasons of the year to meet market needs for milk production.

4.10.2 Economic losses in production

(a) loss in milk production per cow

(b) penalties for inability to meet fluid market demands during the summer season.

CHAPTER V

MILK PRODUCTION PERFORMANCE OF BREEDS OF CATTLE AND BUFFALO UNDER TROPICAL CONDITIONS

The high producing dairy cow is one of the most efficient animals in converting feed protein to milk protein. This fact has stimulated interest (Loosli, 1969) in the development of a dairy industry in the Philippines. However, Rigor (1967) had pointed out that the dearth of dairy animals is the greatest problem of the dairy industry in this area. It has been stated also that no tropical country has ever "produced good dairy breeds of animals"!

5.1 Milk composition of cows and buffaloes

Sen and Dastur (1948) concluded from their studies that the average fat percentage of the milk of the Zebu breed of cows was higher than that of most European breeds, while both the fat and the solids-not-fat content of the milk of buffalo were higher than that of both Zebu and European breeds of cows. Data for fat, protein, lactose and chlorice contents of milk of the three breeds of Indian cows and buffaloes (Singh, 1961) is shown in Table 30.

TABLE 30: Composition of Indian Cows and Buffaloes Milk

Breed	No. of Samples	Percentage			
		Fat	Protein	Lactose	Chloride
Cow: Sahiwal	22	5.3	3.53	4.56	0.12
Hariana	23	5.9	3.63	4.76	0.11
Local (unclassified)	25	4.3	3.71	4.87	0.11
Buffalo: Murrah	25	7.7	3.97	4.99	0.097
Graded	20	6.8	3.67	5.03	0.097
Local (unclassified	25	7.0	3.80	4.99	0.091
Market milk	30	5.8	3.67	4.87	0.096

5.2 Cattle performance in tropical conditions

In the Philippines, for over fifty years now (Rigor, 1967) the government has been importing dairy breeds such as Holsteins, Jerseys, Ayrshires and Brown Swiss, for acclimatization trials. So far, these breeds have not been very successfully raised. However, at Grassland Farm and the Canlubang Farm, both in Laguna, Philippines, some success has been achieved in this direction. Indian breeds of dual-purpose cattle - Red Sindhi, Tharparker and Sahiwal, together with Murrah buffalo have also been imported. These animals thrive well and produce milk under Philippine conditions. Red Sindhi, Tharparker and Sahiwal produce an average of over 4 litres of milk a day, while the Murrah buffalo produces an average of 5 litres. Similarly, at the Dairy Training and Research Institute in Los Banos, Laguna, Philippines, it was reported by Eusebio (1967), that Holstein and Red Sindhi crosses have been found to be adaptable to a warm climate and to provide good yields of milk. Twelve litres of milk daily, and sometimes up to 20 litres a day, have been recorded. Crosses between Red Sindhi bulls and Batangas cows (Philippine cow) produced an average of 4.5 litres a day during the whole lactation period, with a maximum of 9 litres per cow a day. Crosses between Holstein bulls and Nellore cows produce no less than 12 litres a day at the height of lactation.

Loosli *et al.*, (1958) summarizes the milk yield and analysis of Philippine cows as shown in Table 31.

Data at Queensland, Australia, as reported by Pegg (1964), shows that the average yield of all cows which were production-recorded under the grade-cattle herd recording scheme rose from 329 gal. and 144 lb. milkfat in 1963 to the levels shown in Table 32. Thus, there is strong evidence that climate is not entirely

TABLE 31:

Cow No.	Age at Freshening	Milk Yield	Lactation Period	Average Daily Milk Yield	Highest Yield in one day
		ml.	days	ml.	ml.
13	About 11 years	828,317	366	2,263.2	2,993
13	" 12 "	562,330	311	1,808.2	4,000
14	" 12 "	7,013	55	127.5	1,475
14	" 13 "	9,168	70	131.0	1,725
26	6 years, 11 months	1,967	35	56.2	118
31	5 years, 4 days	4,777	44	108.6	722
31	5 years, 10 months, 28 days	35,167	144	244.2	2,218
34	5 years, 4 months, 1 day	70,299	130	540.8	1,590
Mean		189,879.7	144.4 ± 13.252	660.4 ± 307.858	1,855.1 ± 434.252

Chemical analysis of milk of Philippine cows

Item	Specific Gravity	Moisture	Protein	Butterfat	Lactose	Minerals
Mean	1.030 ± 0.002	85.37 ± 1.02	5.7 ± 0.4	4.56 ± 0.71	5.91 ± 0.69	0.96 ± 0.05
Range	1.0224-1.0409	76.06-89.77	0.14-5.86	1.20-12.10	0.58-12.38	0.60-1.64

TABLE 32: Milk Yield Performance of Philippine Cows

Breed	Milk (gal.)	Milkfat lb.	Milkfat %
Australian Illawarra Shorthorn (A.I.S.)	733	290	4.0
Ayrshire	690	282	4.1
Friesian	735	251	3.4
Guernsey	623	282	4.5
Jersey	549	275	5.0

Differences in average productivity of dairy cattle in some temperate and tropical countries are shown in Table 33.

TABLE 33: Average Yield of Cows in Queensland

Country	Climate	Average milk yield of dairy cattle (kg (lb) per annum)
Kenya	Tropical Dry and montane	550 (1,213)
Niger	Tropical Dry	130 (287)
Brazil	Tropical to sub-tropical Humid and dry	820 (1,808)
Colombia	Tropical Humid, dry and montane	680 (1,499)
Trinidad	Tropical Humid	1,778 (3,920)
United States	Temperate Humid and dry	4,631 (10,209)
India	Tropical to sub-tropical Humid and dry	486 (1,071)
Philippines	Tropical Humid	1,237 (2,727)
United Kingdom	Temperate	4,204 (9,268)
New Zealand	Temperate	3,085 (6,801)

Source: FAO (1974)

Low production in the tropics (Williamson and Payne, 1978) is due to the interactions of climate, diseases, breeding and feeding management factors.

A large amount of data has been published on the milk performance of cattle under tropical conditions. The following table includes a summary of this data (Table 34).

TABLE 34: Summary of data on age at first calving and milk production of indigenous cattle

(a) Western Asia and North Africa

Breed	Age at first calving (months)	Milk production: Per lactation kg, Normal range	Milk production: Per lactation kg, Maximum	Milk production: Length of lactation (days)	Milk production: Fat %	Calving interval (months)
Humpless						
Oksh	-	600-907	-	150-250	4.0-5.0	-
Libyan	-	454-1361	2000	200-320	3.2	-
Brown Atlas	22-24	450-600	1200	150-180	4.0	-
Humpless x humped						
Damascus	-	1500-3000	5000	190-300	4.0-5.0	-
Lebanese	-	1000-2500	3000	-	4.0-5.0	-
Persian	-	300	-	-	-	-
Egyptian	32-54	907-1587	-	180-280	-	10-17

(b) North-East and East Africa

Breed	Age at first calving (months)	Milk production: Per lactation kg Normal range	Maximum	Length of lactation (days)	Fat %	Calving interval (months)
Humped						
Sudanese	24-54	454-2723	4659	168-339	4.7-5.5	12-24
Abyssinian	-	450	-	255	6.5	-
Boran	36-52	454-1814	2641	139-303	4.1-6.8	11-14
Small East African Zebu						
Mongalla	-	200-300	-	210-240	6.0-6.5	-
Bukedi	25-61	227-998	1941	223-280	4.7-7.1	11-14
Nandi	43	340-1134	2265	175-300	5.5-6.1	11-13
Tanzania Zebu	36-42	227-544	1205	247-301	4.9	11-13
Zanzibar Zebu	-	227-680	998	247-372	-	-
Humpless x humped						
Nilotic	-	900	-	263	-	-
Danakil	-	200-300	-	160-225	-	-
Ankole	42-60	318-817	898	212-239	3.0-7.0	16-24
Tuni	-	454-1361	1979	252-305	5.3	12-14
Nganda	24-55	136-1134	2791	247-380	4.7-7.1	14
Alur	-	240-1200	-	240-300	-	-

(c) Indian Sub Continent and Ceylon

Breed	Age at first calving (months)	Milk production: Per lactation kg Normal range	Maximum	Length at lactation (days)	Fat %	Calving interval (months)
Humped						
Bhagnari	29-50	454-1588	2268	260-340	5.2	13-15
Gaolao	-	817-1207	-	250-280	5.5	13-15
Hariana	32-72	635-1497	4540	260-320	4.0-4.8	19-21
Krishna Valley	48	499-1361	-	260-320	-	-
Mewati	48	-	1134	-	-	-
Nagori	40	680-1361	1588	220-320	-	15-16
Ongole	36-51	1179-1633	3266	300-330	5.1	16-18
Rath	-	817-1633	2586	200-360	-	-
Gir	31-51	1225-2268	3175	240-380	4.8-4.6	14-16
Dangi	-	454-907	-	260	4.3	-
Deoni	46	680-1134	-	306-310	-	15
Nimari	48-54	272-907	-	-	4.9	18
Dhanni	30-40	680-1134	1361	220-250	-	13-34
Red Sindhi	30-43	680-2268	5443	270-490	4.0-5.0	13-18
Sahiwal	30-43	1134-3175	4534	290-490	4.0-6.0	13-18

cntd

Kankrej	33-78	680-2495	3311	250-370	4.6-4.7	-
Malvi	39-66	680-1361	-	200-340	-	-
Tharparkar	24-47	680-2268	4673	280-440	4.2-4.7	14-18
Amrit Mahal	33-39	680-1361	-	-	-	20
Hallikar	39-69	227-1134	-	180	-	14
Kangayam	39-47	227-1134	2270	220-310	5.7	-
Khillari	38-45	Sufficient for calf only	-	150	-	14-15
Kumauni	-	227-680	907	150	5.3	14
Lohani	-	227-907	1588	200-220	-	-
Sinhala	27-43	227-544	-	230-280	5.0-6.0	12
Humpless x humped						
Siri	60-63	454-1361	1905	280	6.0-10.0	12-20

(d) China and South-East Asia

Breed	Age at first calving (months)	Milk production				Calving interval (months)
		Per lactation kg		Length of lactation (days)	Fat %	
		Normal range	Maximum			
Humpless						
Chinese Yellow	23-30	14-284	-	50-200	5.9	23-29
Batangas	-	-	700	35-366	4.0-5.4	-
Humpless x humped						
Thai	-	260-580	-	-	-	-
Box (bibos) x humpless						
Grati	-	2500-3000	3743	-	-	-

(e) West Africa

Breed	Age at first calving (months)	Milk production				Calving interval (months)
		Per lactation kg		Length of lactation (days)	Fat %	
		Normal range	Maximum			
Humpless						
Kuri	36-43	360-800	1800	180-300	-	-
N'Dama	27-72	150-270	450	150-300	6.5-7.0	14-42
West Coast Shorthorn	30-48	120-360	-	120-180	-	14-24

cntd

Humped						
Maure	36-48	600-700	2000	210-240	-	-
Azaouak	27-46	360-670	1500	180-300	3.0-6.0	-
Shuwa	45	454-1814	3421	240-396	-	18
Sokoto	36	454-1361	1940	230-283	5.8	15
Adamawa	36-48	680-962	1724	100-300	-	12-14
Senegal Fulani	24-60	450-500	-	180-200	5.5	14-24
Sudanese Fulani	36	450-500	1041	150-180	4.8	14-24
White Fulani	36-48	635-1225	2302	190-360	5.0-7.5	12-15
Red Bororo	-	360-600	1361	180-210	6.0	-

McDowell (1972) has presented on the milk production of indigenous and of crossbred cattle as shown in Table 35.

It will be noted that the crossbred cattle all exceeded the random sample of indigenous cattle in milk production, and that crossbreds of at least 50 per cent temperate-type breeding exceeded the best of the tropical breeds in milk yield.

5.3 Buffalo performance in the tropics

The buffalo has certain outstanding qualities which help to account for its popularity (Cockrill, 1967). It is very docile and is customarily handled by women and quite small children. The breeds of milking buffaloes includes the Murrah, the Nili, the Ravi, the Jaffarabadi, the Surati and many crosses and nondescripts which are the result of generations of haphazard breeding, but which make a notable contribution to milk supplies.

As a dairy animal the buffalo is found at its best in India, Pakistan, Egypt and Iraq. Even though milking buffaloes constitute only about 40 per cent of the total milking stock in India, it is the buffalo and not the cow that is principal dairy animal in that country (Williamson and Payne, 1978). The buffalo in India and Pakistan may be as low as 2 to 2.5 litres and as high as 20 litres or more for a good buffalo on a well-managed farm.

TABLE 35: Average performance of groups of dairy cattle in the tropics*

Group	Number of records	Milk yield (kg (lb))	%†	Lactation length Days	%†	Calving interval Days	%†	Age at first calving Months	%†
Indigenous									
Random sample	2,338	631 (1,391)	21	190	57	400	92	41.8	134
Selected	1,464	1,444 (3,184)	49	278	83	437	101	42.4	135
Crossbreds: random sample									
One-quarter temperate type	431	633 (1,396)	21	158	47	393	91	40.5	129
One-half temperate type	990	1,843 (4,063)	62	278	83	414	96	35.0	112
Three-quarters temperate type	210	2,074 (4,572)	70	312	94	331	102	34.0	112
Seven-eighths temperate type	27	2,323 (5,121)	78	295	89	430	99	37.8	121
Exotic temperate type	1,273	2,974 (6,557)	100	333	100	433	100	31.3	100

* Data from forty-eight herds managed at locations of less than 2,000m (6,562 ft.) altitude
† Percentage of data for exotic temperate-type cattle.

According to Williamson and Payne, 1978) four well-managed farms in Pakistan showed an average yield of over 1,860 litres per lactation with the range varying from over 1,507 to 2,128 litres. Average milk yield in Egypt for buffaloes maintained at government farms and research stations is 1,814 litres per lactation. In the Philippines, where working swamp buffaloes are milked, a yield of 2 to 3 litres a day is very common.

The table below (Table 36) shows the performance of different breeds of buffaloes (Cockrill, 1976).

TABLE 36: Performance of Different Breeds of Buffaloes under Chinese Conditions

Breed	Average Milk Yield (kg)	Gestation Period (days)	Fat (%)	Lactation Length (days)
Shui Nin	300	312	11.00	300
Murrah	1,387	305	7.00	-
Native	751	-	9.81	-
Murrah x Shui Nin	1,658	-	8.87	252
Wen Choe	774	305	9.5-10.5	305

5.4 Composition of the milk of the buffalo

The milk of buffaloes has unusual qualities. It meets certain specific food requirements of the human population in India and elsewhere. The fat content can, exceptionally, be as high as 15 per cent; the probably overall average is 7 per cent (Cockrill, 1967). The average solids-not-fat content varies approximately between 9 and 10.5 per cent. Yields vary according to management practices and breeds. The lactation period shows variation, but probably averages some 300 days.

The composition of buffalo milk, compared with that of Western Zebu cows, is shown in Table 37.

TABLE 37: Gross composition of buffalo milk compared with that of Western and Zebu cows (averages of bulk milk)

Type of milk	Percentage by weight					
	Fat	Protein	Lactose	Total solids	Water	
	.... Percentage				....	Calories/ 100g
Buffalo	7.64	4.36	4.83	17.96	82.04	109
Western cow (*Bos taurus*)	3.90	3.47	4.75	12.82	87.18	70
Buffalo diluted to same total solids as western cow	5.49	3.17	3.45	12.82	87.18	78
Zebu cow (*Bos indicus*)	4.97	3.18	4.59	13.45	86.55	78
Buffalo diluted to same total solids as Zebu (*Bos indicus*) cow	5.73	3.26	3.85	13.45	86.55	82
Human	3.9	1.3	7.0	12.45	87.55	69

The estimated population and production of domestic buffaloes by region and by country is shown in Table 38.

TABLE 38: Number of domestic buffaloes and current annual milk production, by region and by country[1]

Region and country	Number of buffaloes (including working animals)	Milk production
	..... Thousand	Thousand metric tons
EUROPE		
Albania	4	1
Bulgaria	74	30
Greece	18	5
Hungary	1	-
Italy	55	31
Romania	75	-
Yugoslavia	54	10
Total Europe	281	77

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U.S.S.R.	460	-
NORTH AND CENTRAL AMERICA		
Trinidad and Tobago	7	-
SOUTH AMERICA		
Brazil	120	-
ASIA		
Afghanistan	35	4
Brunei	18	-
Burma	1,600	30
Hong Kong	1	-
India	54,500	13,400
Indonesia	2,700	-
Iran	280	46
Iraq	290	23
Khmer Rep.	910	-
Laos	940	-
Malaysia		
Sabah	78	-
Sarawak	8	-
West Malaysia	223	7
Nepal	3,480	375
Pakistan	12,100	7,350
Philippines	4,500	20
Portuguese Timor	124	-
Singapore	3	-
Sri Lanka	720	34
Syria	2	-
Thailand	6,950	5
Turkey	1,117	270
Viet-Nam. Dem. Rep. of	1,700	-
Viet-Nam. Rep. of.	565	-
Total Asia	93,712	21,564

[1] FAO Production yearbook 1971, Vol. 25, 1972

CHAPTER VI

GENETIC IMPROVEMENT OF TROPICAL BREEDS FOR MILK PRODUCTION

The paramount objective of a herd management programme (Noble *et al.*, 1972) is to increase the profitability of dairy-farming. The pathways for increased efficiency are considered to be (1) changed environment through improved management, and (2) genetic gain through the use of superior sires and dam in succeeding generations. Palad (1976) stated that one of the most important factors influencing the profitability of cattle production is the standard of management given to the breeding cows. When breeding cows are properly fed and managed, calving percentages may be between 80 and 90 per cent, or even higher; cows which are poorly fed and badly managed may have a calving rate as low as 40 to 50 per cent. Since the profitability of cattle raising is largely determined by the number of calves weaned, it is obvious that a well-managed herd of breeding cows is an essential component of an economically viable cattle raising enterprise.

In the past, the introduction of high-producing temperate-type cattle into tropical countries, either as pure-breds or in order to grade up indigenous stock was considered a panacea for the low productivity (Payn,e 1957) of dairy cattle in the tropics. Time has shown that the introduction of purebred temperate-type cattle is a complete failure, and most authorities now suggest that the only possibly policy that can replace it is one that concentrates on utilizing the breeding techniques that have been evolved in the temperate zone, as part of a crossbreeding programme. It has been shown (Hancock, 1954) at several centres that cattle are best acclimatized to the cold climate regions in the world. It may therefore be a very difficult task to raise the productivity of indigenous cattle to the level of temperate-type cattle in the temperate zone. Tropical-type cattle may be acclimatized to a tropical climate partly because they are relatively unproductive, though of course they are better acclimatized than temperate-type cattle to drought and to tropical diseases and parasites. Mahadevan (1966) stated that "high-producing breeds have a low adaptability reserve towards poor environmental conditions compared with less productive primitive breeds". Also, it is well-known fact that improvement is impossible when the environment does not permit phenotypic expression of the genetic potential of the animals concerned (Miller, 1968).

6.1 Systems of utilization of livestock in the tropics

Several different breeding systems, aimed at the genetic improvement of tropical breeds, have been studied. Application of any of these systems in any one area must take into account many factors including features of the local soil, climate and topography, and the particular type of animal production desired.

6.2 Use of suitable breeds/breeding systems

For short-term programmes in the development of the dairy industry in warm climates (Eusebio, 1967) top-crossing can be a means by which sires of a number of high-yielding breeds such as Red Sindhi, Sahiwal and Tharparkar, can be used over the existing level of high-grade cows. It may be possible to use artificial insemination by importing frozen semen from superior bulls to upgrade local cattle herds.

For a long-term breeding programme, a dairy breed or breeds could be developed, preferably based on 3/4 European (Holstein) and 1/4 Native or Indian blood.

6.2.1 The use of selection within indigenous breeds

The advantages of using indigenous breeds (Williamson and Payne, 1978) are that they are readily available and that they are acclimatized to the local environment and probably possess desirable genetic traits associated with their acclimatization. Efforts should, of course, be made to improve the present productivity of these indigenous breeds by intense selection, including performance and progeny testing, where the use of these methods can be economically justified. In addition it is vitally important that at least limited numbers of all indigenous breeds should be conserved in their specific environments as a future source of genetic variation.

6.2.2 The importation and use of exotic breeds

The advantages of importing exotic livestock are that a rapid improvement in productivity may be achieved (Williamson and Payne, 1978) if suitable animals are used and/or local environmental conditions are sufficiently improved, as exotic livestock can be selected that possess desirable traits unavailable in local livestock populations.

6.2.3 Crossbreeding/Upgrading of indigenous breeds

Branton *et al.*, (1966) concluded that there was some evidence of heterosis for growth rate, milk yield and tolerance to high temperature among the progeny of Red Sindhi cows crossed to Brahman sires. In European-Zebu crosses (Pearson, *et al.*, 1968) progeny have averaged 15 per cent higher in bodyweight at birth, 12-20 per cent at one year of age, and 6.20 per cent higher at two years of age than contemporary Zebus. Table 39 and 40 show the performance of some European crosses with a native cattle (McDowell, 1972). Literature summarized by Mason (1966) and Cundiff (1970), together with more recent data on the Fort Robinson heterosis experiment (Cundiff, 1973) all indicate that the cumulative advantage of crossbreeding over purebreeding can exceed 20 per cent in terms of weight of calf per cow year.

Pearson and McDowell (1967) have pointed out that many experiments of dairy cattle in temperate zones have not been designed to provide estimates of heterosis. Nevertheless, results have shown strong evidence (Robertson, 1949) of positive heterosis for traits which are of economic importance to the dairy industry, principally survival rates, growth rates, and first lactation milk production - at least in progeny of Friesian sires and Jersey dams.

6.3 Performance of graded-up cattle under good managerial conditions

Madsen and Vinther (1975) concluded that, under exceptional managerial conditions, milk production increases as the percentage of temperate-type blood in the cattle increases as shown in Table 41. Unfortunately, however, the data also shows that the reproductive efficiency, as expressed by the length of calving interval, declines. In addition, they have shown that even where health standards and care are exceptional, the percentage of abortions and stillbirths increases as the percentage of temperate-type blood in the cattle increases, as does total mortality up to first calving.

TABLE 39: Average performance of "selected" and "random" groups of native cattle versus average performance of crosses with 1/4, 1/2, 3/4 and 7/8 fractions of European breeding and pure European breeds.

Breed group	No. of countries	No. of breeds		No. of records	Milk yield		Lact. length		Calving interval		Age 1st calving	
		Nat.	Eur.		Mean (kg)	%[a]	Mean (days)	%	Mean (days)	%	Mean) (mo)	%
PURE NATIVE												
Selected	3	3		1464	1444		278		437		42.4	
Random	6	6		2338	631		190		400		41.8	
Avg. all	7	8		3802	944		219		410		42.0	
¼ EUROPEAN CROSSES												
Selected[b]	1	2	2	123	1727	120	313	113	419	96	36.0	85
Random	2	2	2	431	633	100	158	83	393	98	40.5	97
Avg. all	2	4	3	554	875	93	192	88	397	97	39.5	94
½ EUROPEAN CROSSES												
Selected	3	3	4	974	2339	162	310	112	400	92	35.0	83
Random	4	4	4	990	1843	292	278	146	414	104	35.0	84
Avg. all	6	7	5	1964	2088	221	293	134	408	100	35.0	83
3/4 EUROPEAN CROSSES												
Selected	2	2	2	386	2222	154	300	108	456	104	36.8	87
Random	3	3	3	210	2074	329	312	164	441	110	34.9	83
Avg. all	4	5	3	596	2170	230	304	139	450	110	36.1	86

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7/8 EUROPEAN CROSSES												
Selected	2	2	2	243	2111	146	288	104	462	106	37.1	88
Random	1	1	2	27	2323	368	295	155	430	108	37.8	90
Avg. all	3	3	3	270	2125	225	288	132	460	112	37.1	88
PURE EUROPEAN												
Native[c]	6	6		1130	2083		244		416		42.6	
European	6		6	1273	2974	144	333	136	433	104	31.3	73

[a] Average percent deviation from herdmates.
[b] ¼ European breed, 3/4 native.
[c] Herdmates to pure European breeds only, not included in mean for Pure Native group.

TABLE 40: Group means and percentage deviation from pure native herdmates, either selected or random bred, for 1/4, 1/2, 3/4 and 7/8 crosses with various European breeds.

Breed group	No. countries	No. breeds	No. records	Milk yield Mean	Milk yield %	Lact. length Mean	Lact. length %	Calving interval Mean	Calving interval %	Age 1st calving Mean	Age 1st calving %
FROM SELECTED GROUPS											
1/4 Jersey	1	1	50	1944	123	345	98	399	97	34.0	92
1/4 Ayrshire	1	2	49	1526	141	286	108	419	95	40.0	93
1/4 Friesian	1	1	24	1548	163	280	108	417	103	37.5	93
1/2 Jersey	1	1	125	2042	140	345	92	396	93	28.6	78
1/2 Ayrshire	2	2	562	2109	166	310	113	384	87	84.9	80
1/2 Friesian	1	2	262	2859	183	307	109	423	97	36.1	87
1/2 Br. Swiss	2	3	85	3172	176	326	109	421	92	32.4	78
3/4 Ayrshire	2	2	69	1459	135	273	109	383	87	38.6	89
3/4 Friesian	1	2	317	2388	168	306	109	416	106	36.4	88
7/8 Ayrshire	1	1	25	780	77	191	78	-	-	47.0	98
7/8 Friesian	1	1	218	2264	128	299	101	462	110	36.0	94
FROM RANDOM GROUPS											
1/4 Jersey	1	1	424	613	359	157	275	392	105	40.4	99
1/4 Ayrshire	1	1	27	1842	228	202	100	443	106	45.5	92
1/2 Jersey	2	2	60	2124	242	292	115	387	81	35.1	70
1/2 Ayrshire	1	1	77	2058	173	282	123	382	93	37.0	76
1/2 Friesian	4	4	542	1628	136	276	117	450	112	33.3	76
1/2 Shorthorn	1	1	311	2111	168	278	117	399	98	36.7	81
3/4 Jersey	1	1	59	2364	188	298	126	359	88	28.9	68
3/4 Ayrshire	1	1	23	2106	261	310	153	419	94	38.4	78
3/4 Friesian	2	2	119	2130	136	316	134	440	104	35.1	82
3/4 Shorthorn	1	1	59	1902	151	309	130	463	114	34.2	81
7/8 Jersey	1	1	25	2870	228	324	137	383	94	26.7	63
7/8 Friesian	1	1	22	2095	172	283	120	450	111	42.4	100

TABLE 41: The effect of the percentage of *Bos taurus* genes on the length of the first calving interval and second lactation yields of dairy cattle in Thailand

Percentage of *Bos taurus* genes	Breed type: foundation females	Number	Length of first calving interval (days)	Second lactation yield (kg)	
				Milk	Butterfat
0	RS and S	36	462	1,000 ± 154	43.04 ± 7.18
37½	T or T_1	7	341	1,193 ± 319	57.04 ± 14.83
50	T	83	383	1,411 ± 114	72.96 ± 5.29
50	T_1	107	391	1,608 ± 106	78.70 ± 4.91
50	RS and S	18	384	2,255 ± 197	101.60 ± 9.18
62½	T or T_1	54	396	1,722 ± 135	77.45 ± 6.28
75	T	72	411	1,996 ± 115	91.56 ± 5.36
75	T_1	156	408	2,210 ± 95	99.89 ± 4.42
87½	T or T_1	53	404	2,238 ± 130	97.39 ± 6.05
100	RD(T)	17	577	2,760 ± 200	114.50 ± 9.31
100	RS(D)	51	544	2,561 ± 199	106.98 ± 9.23

Note: The abbreviations for the breed types are: RS, Red Sindhi; S. Sahiwal: T. Thai: T_1. Thai improved: RD(T), Red Danish born in Thailand: RD(D), Red Danish born in Denmark.

Source: Madsen and Vinther (1975).

In summary, the genetic improvement of tropical breeds for milk production requires consideration of the following procedures (Williamson and Payne, 1978):

(1) The utilization of indigenous breeds of cattle that are already well-adapted to the environment with selection for high productivity.

(2) The importation of highly productive, temperate-type cattle with selection for adaptability to the trpical environment.

(3) The importation of highly productive, temperate-type cattle and management of them so that the adverse effects of the tropical environment are ameliorated, and

(4) The importation of highly productive, temperate-type bulls and/or semen for use in up-grading less productive indigenous cattle. This could be a continuing process or an effort could be made to stabilise one or more specific crossbred types.

It seems clear that there is no common formula for the genetic improvement of tropical stock (Mahadevan, 1966) for milk production. Inadequate genetic variations in characters of economic importance might be a limiting factor in attaining increased production. The problems associated with the breeding of dairy cattle in the tropics may, therefore be broadly divided into parts: (1) those arising from the natural environment, and (2) those arising from low productivity of native stock.

Artificial insemination among indigenous cattle is too low as a method of improvement. Current thinking on breeding for milk production in the intensive areas of the tropics favours the use of crossbred animals.

The most outstanding results from crossing *Bos taurus* and *Bos indicus* (Mahadevan, 1966) cattle are in regard to milk yield. *Bos taurus* crossed with *Bos indicus* cattle have given a higher yield than *Bos indicus*-type in the high-altitude and maritime areas of the tropics where the rigours of a truly tropical climate are minimized.

CHAPTER VII

NUTRITIONAL LIMITATIONS TO MILK PRODUCTION BY CATTLE AND BUFFALO IN THE TROPICS

It is estimated that nearly one-half of the total cattle population of the world is located in the tropics (Hardison, 1968). The rations consumed by these stocks are composed largely of stubble or herbage in one form or another. Seed crops are required for human consumption and the feeding of grains and concentrates as supplements is frequently looked upon as an expensive luxury. Thus, the production of livestock products in these areas is essentially a function of the yield and utilization of grass, and other things being constant, progress in the former will invariably result from an improvement in the latter. Nutritional standards for dairy cattle have been devised almost entirely (Payne, 1957) in temperate countries and have been applied to the feeding of dairy cattle in the tropics. Indirectly, the climatic environment affect the nutritive value of forage. There is evidence that the quality of tropical forage is low (Payne and Laing, 1952). The majority of tropical forage plants mature quickly, and as the crude fibre content increases and the crude protein content decreases with maturity, the nutritional quality of tropical forage rapidly declines with age.

The tropical regions of the world have the greatest potential (De Guzman, 1978) for increasing the production of roughages, crop residues and by-products, and consequently of increasing ruminant production. There is a vast supply of farm and industrial by-products which cannot be directly eaten by humans, but which can be led to ruminant for conversion into animal protein. The efficient utilization of these materials is one way by which the current shortage of protein in most tropical countries could be alleviated.

Internationally, Hutton (1970) has vigorously defended that view that pasture production must continue to play an important role in dairy cattle nutrition. The choice of pasture species should aim at providing herbage of good nutritive value over as long a period of the year as possible, while ensuring the continued productivity of the pasture for many years (Thurbon, *et al.*, 1971).

7.1 Factors affecting the nutritive value and yield of forages

The composition of tropical forages has many of the same variations as found in temperate forages (Grant *et al.*, 1973). For example, energy and protein content decline in digestibility as the forages mature (Hardison, 1966; Butterworth *et al.*, 1971).

7.1.1 Botanical composition

Forages differ in composition; hence it is necessary to know the composition of each particular forage as this will affect its nutritive value. Table 42 shows the proximate analysis of a grass under Philippine conditions (Loosli *et al.*, 1958).

For more complete information regarding the nutrient content of common feedstuffs, (Williamson and Payne, 1978) indicated the different grasses and other feedstuffs used in tropical countries (Table 7.1.1.(b)).

TABLE 42: Proximate and mineral element composition

Sample		Dry Matter	Protein	Butter Extract	Crude Fibre	N-Free Extract	Ash	Calcium	Phos-phorus	Cobalt	Copper	Sulphur
		%	%	%	%	%	%	%	%	%	ppm	ppm
Alabang x (Andropogon nodosus (Willem) Nash.)	1[a]	91.8	5.8	1.8	36.1	36.4	11.7	0.38	0.25	0.10	7.9	.23
" " "	2	92.4	6.4	0.9	37.0	35.4	12.7	0.29	0.16	0.10	4.6	- b
" " "	2	92.7	4.8	1.6	35.9	41.0	9.4	0.28	0.20	0.08	3.7	.06
" " "	4	90.3	9.9	1.4	32.2	38.5	8.3	0.28	0.27	0.09	8.1	.25
Alfalfa, before bloom	5	93.0	21.7	3.6	23.8	35.1	8.8	1.18	0.31	0.25	9.0	.33
" " "	2	91.8	21.4	3.1	22.9	35.9	8.5	0.94	0.29	0.19	9.2	- b
Bagocboc lalake	4	91.1	6.2	0.8	30.6	41.5	12.0	0.51	0.13	0.10	4.6	.07
Bermuda grass		90.8	10.7	0.8	27.6	40.8	10.9	0.50	0.21	1.80	23.3	.45
Bukidnon grass		90.4	3.5	0.8	35.5	41.8	8.8	0.21	0.12	0.15	2.9	.07
Bungalon (*Echinochloa stagnina* Beauv.)		92.8	5.7	1.0	30.5	46.6	9.0	0.36	0.27	0.89	15.6	.31
Centrosema pubescens Benth.		91.9	17.0	1.7	39.7	28.5	5.0	0.79	0.19	0.26	17.9	- b
Cogon (*Imperata cylindrica* (Linn.) Beauv)		92.3	6.8	1.9	36.7	38.9	8.0	0.51	0.25	0.54	7.3	- b
" " "	1	93.0	3.8	1.2	36.7	54.9	6.4	0.36	0.10	0.12	3.3	.05
" " "	2	92.7	7.4	1.6	35.8	40.4	7.5	0.20	0.22	0.16	4.8	- b
" " "	3	92.2	8.3	1.3	36.3	38.9	7.4	0.21	0.14	0.10	6.0	.11
" " "	4	91.4	7.6	1.0	33.8	41.6	7.4	0.24	0.15	0.13	5.2	.11
Calopogonium mucunoides Desv.		91.7	12.3	2.8	42.5	26.0	7.1	1.39	0.20	0.55	12.1	.23
Culape (*Paspalum conjugatum* Berg.)		89.6	7.3	0.8	25.9	45.4	10.2	0.33	0.20	1.55	11.0	.08
Guinea grass (*Panicum maximum* Jacq.)		91.0	7.4	1.1	33.2	37.9	11.4	1.09	0.18	0.24	8.7	.21
Misamis grass (*Andropogon micranthus* Kunth.)	1	92.9	8.2	1.9	28.3	47.7	6.8	0.23	0.15	0.13	6.5	.06
Molasses grass		89.6	5.6	1.2	31.5	42.8	8.5	0.13	0.24	0.92	7.9	.14
Natal grass (*Rhynchelytrum roseum* (Ness) Stapf and Hubb)		93.7	3.8	1.3	40.9	42.0	5.7	0.32	0.14	0.22	3.3	- b
Para grass (*Panicum purpurascens* Raddi)		91.5	7.7	1.3	35.0	38.2	9.3	0.26	0.22	0.27	12.1	.32
" " " "	2	91.3	10.1	2.2	29.5	40.4	9.1	0.22	0.32	0.74	9.0	.23
" " " "	3	91.7	11.8	1.4	29.0	39.9	13.6	0.32	0.25	0.19	13.3	.31
" " " "	3	92.6	11.6	1.8	28.9	39.8	14.5	0.35	0.25	0.23	14.6	.29
" " " "	4	93.0	6.5	1.0	34.2	42.1	9.2	0.18	0.28	0.09	11.0	.21

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TABLE 42: cntd

Sample	Dry Matter	Protein	Butter Extract	Crude Fibre	N-Free Extract	Ash	Calcium	Phos-Phosus	Cobalt	Copper	Sulphur
	%	%	%	%	%	%	%	%	%	ppm	ppm
Para grass (*Panicum purpurascens* Raddi) 4	92.9	6.6	1.8	33.2	42.2	9.3	0.17	0.30	0.08	7.9	.19
Culape (*Paspalum conjugatum* Berg.)	92.7	5.3	0.9	32.5	44.0	10.0	0.49	0.11	0.38	5.2	.30
Tropical kudzu (Pueraria javanica Benthl)	90.8	13.8	1.7	46.1	20.6	8.6	0.81	0.23	0.74	17.9	.33
" " " " 1	92.7	17.8	1.3	26.0	40.0	7.0	1.19	0.15	0.25	8.1	.22
" " " " 1	92.2	13.5	0.7	38.2	33.7	6.1	0.91	0.23	0.17	12.9	- b
" " " " 2	91.2	17.4	2.3	33.2	32.4	5.9	0.68	0.28	0.16	11.5	.23
" " " " 3	92.2	18.1	0.6	31.6	35.5	6.4	0.77	0.21	0.33	12.5	.23
" " " " 4	91.7	15.6	1.2	34.1	34.0	6.8	0.92	0.16	0.13	9.8	.16
Silibon grass	92.9	5.2	1.2	31.7	55.4	9.4	0.35	0.16	0.16	3.7	.05
Mixed pasture grass	91.6	7.8	1.3	29.3	42.3	10.9	0.35	0.14	0.16	5.2	.08
Unidentified grass	90.3	6.3	0.5	34.5	37.2	11.8	0.33	0.10	0.38	6.0	.16
" "	92.2	5.7	1.9	30.5	46.6	9.0	-	-	-	-	- b
White Flint corn grain	90.4	10.9	4.5	2.8	71.3	0.9	0.004	0.26	0.03	2.9	.16
Approx. requirement for growth	-	-	-	-	-	-	0.30	0.25	0.07	4.5	-

a. The forages were obtained from the Central Experiment Station, College, Laguna unless otherwise noted, as follows:
1. Bongabon Stock Farm, Nueva Ecija, Luzon; 2. Dumarao Stock Farm, Dumarao, Capiz; 3. La Carlota Stock Farm, La Carlota, Negros Occidental; 4. Milagros Stock Farm, Milagros, Masbato and 5. Canlubang Sugar Central, Laguna.
b. Not determined because of insufficient sample.

TABLE 43: Nutrient content of common feedstuffs

	DM %	Dry matter basis DE (kcal) per kg	per lb	DCP %	D Value
GRAZING OR SOILING FORAGES					
Beans, velvet, whole plant flowering	25	2552	1160	12.6	58
Clover, subterranean, second year	19	2904	1320	18.4	66
Columbus grass, young	21	2734	1240	12.5	62
Desmondium unicinatum (Spanish clover)	20	2778	1260	10.8	63
Glycine javanica, leafy	26	2376	1080	15.2	54
flowering	27	2332	1058	16.1	53
Glycine javanica with napier grass 3.5 months' regrowth	22	2376	1080	10.5	54
Grassland, natural, at seeding, approximate altitude 1000m (3,300 ft), Kenya. DM not determined					
Aristida adscenionis	-	1808	820	1.5	41
Chrysopogon aucheri	-	1676	760	1.8	38
Eragrostis superba	-	1632	740	3.1	37
Helictotrichon cartilapeum	-	1720	780	0.5	39
Heteropogon spp.	-	1720	780	0.6	39
Grassland, natural, very mature, approximate altitude 2000m (6,000 ft), Kenya.					
Hyarrhenia spp. predominant	70	1190	539	0.6	28
Guinea grass, coloured, 1 month's regrowth	15	2822	1280	10-14	61-66
giant, 1 month's regrowth	15	2734	1240	13.0	62
3.5 months' regrowth	26	2300	1042	8.7	51-53
Kale	12	2926	1330	15.8	67
Kikuyu grass, 1 month's regrowth	18	2778	1260	18.5	63
2 months' regrowth	23	2602	1180	12.9	60
3 months' regrowth	25	2816	1286	8.0	59
Dry season carryover	31	2110	961	2-3	48
Lucerne	25	2610	1184	14.0	59
Napier grass, 1 month's regrowth	23	2500	1132	9.1	52-58
7 months' regrowth	26	1956	878	2.1	43-45
Pangola grass, young	21	2550	1158	8.7	58
flowering	23	2420	1098	5.3	55
mature	27	2350	1068	0.8	53
Rhodes grass, 1 month's regrowth	20	2816	1282	9.0	64
2 months' regrowth	23	2580	1160	5.0	58
4 months' regrowth	26	1940	880	2.0	44
Setaria, Nandi, 1.5 months' regrowth	21	2728	1238	9.5	62
4 months' regrowth	29	1930	876	3.6	45
Sorghum/sudan grass, hybrid, early growth	20	2880	1285	8.0	63
Star grass, 2.5 months' regrowth	23	2275	1050	4.5	53

cntd

TABLE 43: cntd

	DM %	DE (kcal) per kg	DE (kcal) per lb	DCP %	D Value
	Dry matter basis				
3.5 months' regrowth	26	2116	960	3.2	48
4.5 months' regrowth	26	2065	915	3.1	48
Sudan grass, early growth	20	2778	1260	8.2	63
Sugar cane tops, fed green	25	2470	1120	2.8	56
Sunflower	21	2142	971	8.6	49
Sweet potato tops	22	2606	1182	8.2	56
SILAGES					
Andropogon gayanus	25	1760	798	1.2-2.7	38-50
Guinea grass, giant	29	1770	802	4.0	46
Hyperrhenia rufa	24	1320	598	0.5	30
Lucerne	30	2500	1136	11.3	73
Maize, dough stage	27	2590	1175	2.8	59
milk stage	25	2728	1240	3.1	62
Maize/cowpea	24	2520	1132	3.0-4.5	50-60
Oats	30	2793	1267	6.0	63
Pea	28	2851	1293	10.7	65
Rhodes grass, mature	28	2024	930	1.6	46
Sorghum/sudan grass, hybrid, mature	29	2350	1068	2.0	55
Sunflower	26	2205	1000	3.5	48
HAYS					
Guinea grass, giant, full seed	91	1980	898	1.2	45
Lucerne, pre-bloom	89	2708	1228	15.3	61
mid-bloom	89	2453	1115	12.1	57
Millet	88	2506	1136	5.7	57
Oats	88	2670	1211	4.5	54
Red oat	90	1716	780	1.5	39
Rhodes grass, early flowering	89	2550	1150	5.0	58
Setaria, full seed	91	1232	559	0.2	28
Sorghum/sudan grass, hybrid	89	2548	1156	5.4	58
Soyabean	89	2328	1056	10.1	53
Star grass	91	2204	1002	4.4	50
STRAWS AND STOVERS					
Barley straw	88	1896	860	0.7	49
Beans, field, haulms	89	2250	1020	3.4	51
Maize stover	87	2432	1106	1.8	55
Millet stover	90	2082	944	1.7	47
Oat straw	90	2302	1044	1.4	52
Rice straw	94	2097	951	0.1	48
Rye straw	89	1960	889	0.0	44
Sorghum stover	92	2205	1000	1.7	50
Soyabean haulms	88	1903	863	1.6	43
Sugar cane Bagasse	90	2009	911	0.0	-
Wheat straw	90	2107	955	0.4	48
CONCENTRATES					
Acacia pods	91	2552	1160	4.5	58
Barley grain	89	3820	1736	9.8	-
Beans, field	90	3820	1736	22.0	-
Brewers' grains, wet	24	2800	1270	19.2	-
Cassava, dried	94	3520	1600	0.1	-

cntd

TABLE 43: cntd

	DM %	DE (kcal) per kg	DE (kcal) per lb	DCP %	D Value
		Dry matter basis			
Citrus pulp, dehydrated	90	3307	1503	3.0	-
Cocoa, meal	96	2783	1265	9.4	-
pods	92	2339	1063	3.8	53
Coconut meal, mechanically extracted	93	3307	1503	17.7	-
solvent extracted	92	3258	1481	18.4	-
Cottonseed, hulls	90	1812	824	0.2	41
meal, solvent extracted	91	3101	1410	37.0	-
meal, whole pressed	90	3087	1403	20.1	-
Fish meal, Tuna	90	2978	1353	47.2	-
Groundnut meal, mechanically extracted	92	3834	1743	45.3	-
solvent extracted	92	3595	1630	46.9	-
Linseed meal, mechanically extracted	91	3586	1626	34.2	-
solvent extracted	91	3441	1560	33.5	-
Lucerne meal, dehydrated, ground	81	2508	1140	16.7	59
Maize, bran	90	3572	1420	8.4	-
bran and germ meal	91	3439	1560	7.4	-
cobs without grain	93	2253	1020	0.0	-
cobs with grain	86	3740	1700	6.0	-
grain	89	3968	1800	7.5	-
gluten meal	91	3779	1714	40.5	-
Meat meal	94	2867	1300	46.6	-
Meat and bone meal	93	2836	1286	42.9	-
Milk, cows', buttermilk	10	3978	1804	31.3	-
separated	9	3752	1702	32.1	-
whole	12	5508	2498	24.2	-
Millet grain	90	3724	1689	9.3	-
Milo grain	89	3934	1784	9.6	-
Molasses, sugar cane	74	3992	1810	0.0	-
Oats	89	3369	1528	9.9	-
Pineapple pulp, dried	89	3162	1434	0.9	72
Potatoes	21	3990	1810	5.7	-
Rice, bran, with germ	91	2956	1341	9.6	-
grain	89	3471	1578	6.7	-
Rye grain	90	3749	1700	11.1	-
Sorghum grain	87	3953	1793	10.3	-
Soyabean	91	3924	1780	36.4	-
Soyabean meal, mechanically extracted	90	3772	1711	41.3	-
solvent extracted	89	3617	1640	46.3	-
Sunflower, bran	90	2867	1300	2.5	-
meal with hulls	89	1764	800	18.3	-
meal without hulls	94	3321	1506	47.9	-
Sweet potato roots	32	3528	1600	0.6	-
Wheat, bran	89	3072	1393	14.0	-
germ meal	90	4164	1889	28.6	-
grain	90	3866	1754	11.1	-
middlings	89	3772	1711	13.9	-

7.1.2 Stages of growth of grasses and legumes

French (1957) pointed out that the essential difference between tropical and temperate grasses in their respective rates of growth is the content of crude fibre and crude protein. Most grasses grown in tropical countries mature quickly (Payne and Laing, 1952) and they may be considered to be of high feeding value for only a relatively short interval during the growth cycle. Table 44 shows the proximate composition of dry matter in varying stages of growth (McDowell, 1972).

TABLE 44: Proximate dry matter (DM), total digestive nutrients (TDN), and crude fibre (CF) content (in percent) of some grasses used for grazing in tropical areas.

Name		Stage of Growth	DM	Proximate composition of DM	
Scientific	Common			TDN	CF
Cynodon dactylon	Bermuda	Immature	19.1	56.9	33.3
		Mature	26.7	43.4	34.9
Cynodon plectostachyum	Star	23 days	20.1	63.8	22.6
		60 days	30.4	49.4	30.2
Digitarias decumbens	Pangola	23 days	20.5	62.4	27.4
		42 days	33.1	58.5	29.3
		84 days	30.7	46.6	30.0
Hyparrhenia rufa	Jaragua	Immature	29.7	54.7	28.9
		Mature	35.5	43.2	33.7
Melinis minutiflora	Molasses	Immature	25.6	52.1	39.5
		Mature	44.8	50.6	42.5
Panicum maximum	Guinea	Immature	25.1	52.3	36.4
		Mature	26.2	38.2	33.8
Panicum purpurascens	Para	Immature	25.4	49.7	34.8
		Mature	27.6	33.7	35.1
Pennisetum clandestinum	Kikuyu	Immature	25.0	69.0	20.9
		Mature	23.7	53.3	24.5
Pennisetum purpureum	Elephant	23 days	20.5	58.3	37.3
		60 days	21.0	48.8	36.4
Tripsacum laxum	Guatemala	Immature	25.3	62.2	35.6
		Mature	20.3	56.7	36.0

Hardison (1974) shows the comparable growth stages in different countries. Many tropical herbages are lower in protein and higher in crude fibre at all stages of maturity than is the case in temperate countries (Table 45).

TABLE 45: Composition of grasses cut at comparable growth stages in different countrie (French (26)).

Species	Country	CP	EE	CF (% DM basis)	NFE	ASH
Napier grass	Venezuela	10.8	1.3	34.1	40.4	13.4
	E. Africa	7.2	1.0	36.1	43.3	12.4
	Hawaii	6.5	2.9	33.4	44.7	12.4
Rhodes grass	Venezuela	5.9	1.6	35.2	42.7	14.5
	E. Africa	9.5	1.7	32.5	44.5	11.8
	Brazil	9.6	2.5	33.3	45.0	9.6
Pangola	Venezuela	9.8	1.4	30.3	46.4	12.1
	Costa Rica	8.5	2.0	24.4	40.5	10.5
Pangola grass (42 days)	Trinidad	4.8	1.0	36.3	51.0	6.9
	Venezuela	9.5	2.0	29.3	46.2	13.0
Guinea grass (80-84 days)	Nigeria	7.2	1.2	32.0	49.3	5.1
	Philippines	5.7	2.9	33.5	44.1	14.4
Guinea grass (21 days)	Nigeria	13.5	1.1	28.3	37.5	11.5
	Philippines	8.8	2.5	31.7	41.6	7.4
Napier grass (56 days)	Nigeria	10.5	1.7	29.5	44.8	7.4
	Hawaii	7.4	2.5	34.4	42.2	13.5
Napier grass (84 days)	Nigeria	9.6	2.2	29.6	47.6	6.0
	Hawaii	4.4	2.3	38.4	42.4	12.6

Table 46 shows the composition of grasses at different locations in Venezuela. The table also shows that dry matter content increases with age, while crude protein content decreases (Grant *et al.*, 1973). The hemicellulose content of the forage of the same age, accounts for the higher total fibre (cell wall) content in tropical forage (Van Soest, 1967). Crude protein levels drop rapidly with age in tropical grasses however, if pasture are managed and grazed rotationally; energy rather than protein will be the main factor limiting production

TABLE 46: Composition of grasses cut at comparable growth stages at different locations in Venezuela

Species and Growth Stages	CP	EE	CF (% DM basis)	NFE	ASH
Rhodes grass (Flowering)	16.7	2.4	34.4	35.4	11.0
	8.0	1.9	34.8	44.9	10.3
	5.9	1.6	35.3	42.7	14.5
Napier grass (Flowering)	11.3	1.5	34.7	41.5	11.0
	10.8	1.3	34.0	40.4	13.4
	9.1	1.4	38.1	41.5	9.9
	7.9	1.2	37.3	42.5	11.0
	4.0	1.5	38.2	45.6	10.6
Guinea grass (Flowering)	16.5	1.7	35.6	38.0	8.2
	14.8	0.9	40.4	30.0	13.0
	13.7	0.9	39.2	34.5	11.7
	12.0	1.6	39.5	38.5	8.3
	10.8	1.1	38.7	33.0	16.3
	9.4	2.1	39.3	37.9	11.2
	8.6	1.3	43.3	34.8	11.9
	7.7	1.9	39.7	42.9	7.7
	5.3	1.9	36.3	43.0	13.5
	4.3	2.6	41.7	43.3	8.1
	4.3	0.8	46.6	37.8	10.4
Guinea grass (Vegetative)	10.5	28.3	1.9	48.8	10.5
	9.9	27.1	2.2	50.7	10.1
	8.0	32.2	2.2	44.8	12.8
	7.3	32.8	1.7	47.9	10.3
	7.1	30.8	1.5	53.4	7.2
	6.3	32.3	1.6	48.6	11.2
Para grass (Vegetative)	12.6	24.6	2.6	45.2	15.0
	6.6	26.6	1.8	52.9	12.1
	6.5	32.1	1.4	50.2	9.8
	3.9	28.6	1.3	59.2	7.0

(Hardison, 1966). Butterworth and Diaz (1970) noted that the digestion of crude fibre was almost invariably higher than that of nitrogen-free-extract. Furthermore, they found that the apparent digestibility of crude protein was of little use for predicting TDN values. They concluded that more sophisticated systems of analysis such as those proposed by Van Soest (1967) have to be employed to determine more accurately the nutritive value and chemical composition of tropical grasses.

7.1.3 Soil fertility

Generally, soils that are rich in bases are usually low in nitrogen but have enough of the most other elements for adequate fertility (McDowell, 1972). Table 47 shows the extent of different types of soil in each of the major rainfall distibution areas in the tropics.

TABLE 47: Classification of tropical land areas by rainfall distribution and soil characteristics (million hectares)

Desert, semi-desert and dry climates	1330
Soils rich in bases	680
Leached soils	130
Shallow soils	490
Alluvial soils	30
Wet-dry climates (4½-7 months humid)	1020
Soils rich in bases	220
Leached soils	560
Shallow soils	170
Alluvial soils	70
Humid summer climates (7-9½ months humid)	1410
Soils rich in bases	60
Leached soils	1120
Shallow soils	100
Alluvial soils	120
Rainy climates (9½-12 months humid)	1190
Soils rich in bases	30
Leached soils	930
Shallow soils	80
Alluvial soils	150
Total	4950
Soils rich in bases	990
Leached soils	2750
Shallow soils	840
Alluvial soils	370

Source: FAO data

In general because of the youthful gelogic character of the country, soils in the Philippines (Payne and Garcia, 1968) tend to show a strong influence of their parent-material. Apart from differences in levels of fertility that can be generall corrected by fertilizer applications, soils can be broadly classified into heavy and light types where poor drainage in the wet season and high water-holding capacity in the dry season have a marked influence of pasture productivity. One of the most important factors from a pasture production point of view is the availability of soil moisture and Rattray (1967) has recently defined those areas where soil moisture is not likely to be a limiting factor at any time of the year. Eusebio (1968) stated that the beneficial effects of the organic matter supplied by legumes and grasses when ploughed under a crop rotation, and added manure from the cow, will result in an increase in forage yield.

Warwick and Bond (1966) concluded that most of the soils in the high rainfall areas of the tropics have been leached of valuable mineral elements, notably phosphorus which makes the forage low in nutritive value.

7.1.4 Climate

In Asia and the Pacific, De Guzman (1975) defined the climate as humid and subtropical with an average rainfall of 1730mm; approximately 60 per cent falls in summer and the balance in winter. Rainfall is unreliable and may vary from less than 760mm to more than 2540mm.

Since plant growth in the humid tropics could be more or less continuous it might be assumed (Hardison, 1968) that little seasonal fluctuations in herbage production exists. The seasonal production of dry matter and protein from Napier grass in Puerto Rico (Anonymous, 1962) is shown in Table 48. Data showed that there was little difference in rainfall between the periods of greatest dry matter production and the period when intermediate yield were obtained. The proximate composition showed the highest values during the period of lowest yield and lowest rainfall. Caro-Costas and Vicente-Chandler (1956); Fegarilla *et al.*, (1964) indicated that low rainfall is associated with low yields of forage. Phillips and Lampin (1964) noted a marked positive correlation between level of rainfall and dry matter yields of Napier grass and Guatemala grass.

TABLE 48: Seasonal effects on dry matter and crude protein yields - Napier grass, Puerto Rico

	DM (lb/acre/mo)			CP (lb/acre/mo)		
Year	May to Aug	Sept to Dec	Jan to Apr	May to Aug	Sept to Dec	Jan to Apr
First	4420	2360	1840	309	219	180
Second	2940	2170	1540	215	176	129
Third	2380	1680	1330	174	151	133
Average	3347	2070	1570	241	182	148
	Mean rainfall (in/mo)					
	6.5	6.0	4.9			

In Nigeria (Paterson, 1966) the dry matter yields of Napier grass were observed to be inversely related to rainfall. However, guinea grass was the most sensitive to moisture level and yields follow the rainfall curve the closest (Anonymous, 1935).

Warwick and Bond (1966) stated that forages in the humid tropics, although abundant, are generally low in nutritive value because of: (a) high water content, (b) higher fibre content, (c) low protein content per unit dry matter, (d) low content of the easily digestible carbohydrates, and (e) the absence of legumes in the pasture.

Most experimental evidence suggests that when temperature is high ruminants fed on a high plane of nutrition are likely to have more difficulty in disposing of body heat than those fed on a low plane of nutrition (Payne, 1966).

7.2 Intake of Pasture by Grazing Stock

The level of animal production secured from tropical grassland (Hardison, 1968) is determined to a very great extent by the intake and digestibility of herbage.

Hardison (1968) concluded that the dry matter intake from fresh forages by grazing cows is approximately 2.5 per cent of their liveweight daily. According to data supplied by Hardison and Castillo (1968), the Philippines grasses contain 80-90 per cent water durin the rainy season. Forage containing 85 per cent water would require a 400kg cow to consume 67kg, if intake, as proportion of liveweight, is 2.5 per cent. Hardison (1968) further reports that energy is the limiting factor in green tropical forage and that the level of energy was never sufficient for the production of more than 4 to 6kg of milk per day. Production of milk above this level (Miller, 1968) would have to come from supplemental feed. In addition to the heat stress from temperature and direct solar radiation, the added heat increment (work of digestion) imposed by the 67kg of high moisture, high fibre (per unit dry matter) forage may exceed the heat-dissipating mechanism of the cow. Under severe heat stress, the cow can consume less forage and production suffers accordingly.

In feeding guinea grass silage Johnson (1966) reported a dry matter intake of 2.2 per cent of liveweight which supported gains of 0.24kg per day in young dairy bulls and 4.0kg per day of milk in Holstein cows. Ordoneza (1967) recorded 2.0 per cent dry matter intake in growing dairy calves fed on silage *ad libitum* plus concentrates at one per cent of their liveweight. Growing calves (Miller, 1968) cannot make normal growth on 2.5 per cent of their liveweight in dry matter from green tropical forage. Furthermore, it is most unlikely they will consume enough of the forage to give a dry matter intake of 2.5 per cent.

In digestibility trials with green fodder, Harrison (1942) obtained an average dry matter consumption of approximately 1.6 lb per 100 lb liveweight and intake was not affected by dry matter of the herbage consumed. On the other hand, Robinson (1950) stated that on the feeding value of tropical fodders for dairy cattle, he had not observed the reduced consumption of dry matter reported by Harrison (1942). Unfortunately, no data were given to support his statement.

In limited trials where the dry matter percentage of herbage was raised from about 20 to 35 per cent by wilting, Harrison (1942) found that the intake of dry matter increased by approximately 60 per cent (2.5 per cent of that intake of bodyweight). Holmes and Lang (1964) concluded that the dry matter intake of grazing cattle feeding on fresh herbage is unlikely to be restricted either by a high internal water content in the herbage or by rain water on the leaf surface. This is similar to the conclusions of Campling (1964). The average dry matter intakes, expressed as per cent of animal liveweight, of several tropical herbages when hand-fed to cattle are summarized in Table 49. Intake varied from slightly more than 0.5 to approximately 3 per cent with an overall mean of 2.13.

In general it appears that concentrates reduced feed intake only slightly (Hardison, 1968). However, the effect of concentrate feeding per se on the intake of tropical forages has not been investigated. Rivera-Brenes (1947) found that although forage intake was influenced by the type or breed of cattle, the differences observed were not great (Holstein - 1.72; Holstein x

TABLE 49: Consumption of fresh tropical forages by cattle.

Herbage fed	Ave. DM intake (% of L.W.)	Stage of maturity	Supplement fed
Napier	1.81	Mature	Yes
Napier	1.88	80 + days of age	No
Napier	2.13	Mature	Yes
Napier	2.26	Young	Yes
Napier	1.25	Not given	Yes
Napier	2.37	42-56 days of age	No
Guinea	2.71	42-70 days of age	No
Axonopus scoporius	2.59	56 days of age	No
Napier	1.89	40-50 days of age	No
Giant Pangola	2.11	40-50 days of age	No
Signal	1.95	40-50 days of age	No
Napier	2.00	40-60 days of age	No
Venezuela	0.69	40-60 days of age	No
Guinea	2.87	41-60 days of age	No
Para + Alabang X	2.57	Not given	Yes
Para	2.44	Not given	Yes
Para	2.18	Not given	Yes
Grass/legume	2.35	Not given	No

Native - 1.82; Native - 2.11 lb dry matter per 100 lb liveweight).

The results of Bredon (1963) indicated that adaptation may be an important factor in determining the animal intake of tropical pasture plants. In trials with cattle fed daily, it was found that, if the stock were allowed to become accustomed to stall-feeding on fresh green (2 months period), the dry matter intake of cattle approached 3 per cent liveweight).

The intake of tropical herbage has been estimated with the grazing animal and Butterworth (1961) obtained a mean dry matter intake of 3.0 and 3.7 per cent of liveweight, respectively. The herbage available from grazing during the wet season contained 23.4 per cent dry matter compared with 39.3 per cent for the dry season. The organic matter figures from grazing European-Zebu-type cattle published by Phillips and Lamkin (1964) are in reasonable agreement with these values. Bennagen *et al.*, (1963) found that the dry matter intake of grazing milking cows to be roughly 2.7 per cent of liveweight. Food intake by the lactating cows is determined by a number of factors related to the cow herself, to the feeds, and to certain aspects of management (Broster *et al.*, 1978).

7.2.1 Animal factors

7.2.1.1 Size - As the abdominal capacity will increase with the size of cow, it will also increase gut capacity and hence intake. During fattening, considerable amounts of fat are deposited in the abdominal cavity; these will effectively reduce rumen capacity and thereby food intake.

7.2.1.2 Milk yield - The increase in intake due to lactation varies according to the type of ration fed, but in general, changes of 30 to 40 per cent are common. However, the relationship between the actual yield and food intake is poor, partly at least owing to the influence of the lactation cycle. Table 50 shows the main trends of milk yield, liveweight and intake over the lactation.

TABLE 50: Trends in milk yield, liveweight and intake over lactation

	Ratio of Concentrates to Hay		
	60:40	75:25	90:10
DM Intake (kg/d)	13.7	13.20	13.7
DE Intake (MJ/d)	171.0	171.1	183.6
Milk Yield (kg/d)	18.7	22.1	22.2
LWC (kg/d)	-0.11	-0.11	0.18

The above table shows that increasing the ratio of concentrate to hay in feeding the lactating animal will increase milk yield, dry matter intake, digestible energy and liveweight.

7.2.1.3 Metabolic factors - If physical limitations to intake do not intervene, the cow will consume as much energy as it can utilize for deposition of body fat. Accumulation of acetate in the rumen, and/or propionate near the liver, are probably the major factors concerned (Baile and Forbes, 1974).

7.2.2 Food Factors

7.2.2.1 Forage type and preparation - The intake of diets high in roughage is generally limited by physical factors. With a very highly digestible forage, the cow may meet her energy requirement fully. Otherwise, there is increasing intake as the quality of forage increases (Blaxter *et al.*, 1961). The effect on intake of grinding roughage decreases as the quality of the roughages increases (Bines *et al.*, 1977).

7.2.2.2 Concentrate forage ratio - Stimulation of roughage intake is low, and that of the supplement is high, when concentrates are added to a diet of poor quality roughage (Campling and Murdock, 1966). In general, supplementation with concentrates will decrease eoughage intake (Broster *et al.*, 1978), and the rate of substitution increases with increasing quality of roughage.

7.2.2.3 Protein content - Reduced protein content of the total ration will depress intake (Elliott and Topps, 1963; Elliott, 1967). The critical level of protein inclusion will depend on the forms in which nitrogen is supplied. The protein level can be as low as 12.5 to 13.5 per cent for good performance of the cow (Thomas, 1971; Van Horn *et al.*, 1976) and higher levels will not improve intake or performance except in very high-yielding cows.

7.2.3 Management Factors

7.2.3.1 Access time to food - The daily maximum voluntary intake occurs in about 6 hours (Wilson and Flynn, 1974). Increasing length of time of access to hay from 5 to 24 hours daily raised intake by only 20 per cent (Freer and Flynn, 1974). In contrast, much larger increases in intake of high-concentrate rations can be achieved by a similar change in time of access (Freer and Campling, 1963; Bines and Davey, 1970). It seems likely that intake of diets of intermediate composition will increase with increasing time of access in relation to the proportions of roughage and concentrates fed. Free access to concentrates generally results in very erratic intakes by dairy cows, leading to little or no improvement in performance compared with controlled feeding (Owen *et al.*, 1973).

7.2.3.2 Frequency of feeding - If the time of access is increased, there is evidence (Kaufmann, 1976) that this can be done effectively by giving several meals. This is particularly the effect, where rations contain high levels of concentrate. In concluding, giving cows continuous access to food throughout the 24-hour period, and letting them decide their own feeding frequency, is the basis of complete diet-feeding.

In summary, the voluntary intake of pasture by grazing stock is a critical factor in determining not only the peak production in lactation but also the total yield over the lactation in dairy stock. Because the digestibility of the forage consumed has a direct effect on the total voluntary intake, and because tropical pastures decline so quickly in digestibility with increasing maturity, a high degree of managerial skill is required to supply lactating cows with forage of optimal composition over the critical early to mid-lactation period, let alone over the whole of the season.

7.3 Management

Improvement of tropical grasslands (Hutton, 1970) was neglected for many years because most of the areas involved are in developing countries with pressing sociological and economic problems. Also, it has been concluded (Whyte *et al.*, 1953) that it would have been very difficult to introduce a legume into tropical grassland and establish a legume-based pasture as productive as those in temperate areas.

7.3.1 Soil

Fertility can be considered as a great complex of characteristics which determines the ability of a soil to produce a crop. For pastoral agriculture, a fertile soil must provide forage in quantities and of a quality which suit animal production (Ball, 1977) Sears *et al.*, 1965) illustrated that raw sub-soil could be converted to highly productive grasslands with five years of good husbandry. Improvement in soil structure was apparent after only one year, with little improvement beyond the third year under pasture.

Phosphorus deficiency limits pasture production on almost all underdeveloped soils. Applying superphosphate removes the phosphorus limitations and coincidentally removes sulphur deficiency (Ball, 1977).

Hardison (1968) pointed out that moisture is the only major limiting factor to herbage growth although supplemental irrigation may be effectively used to increase dry matter production.

In land preparation, cultivated pasture must be treated as a crop and the land prepared accordingly (Williamson and Payne, 1978). For seeded pastures, the soil should be weed-free and consolidated, but the tilth should not be too fine. In using fertilizers we should understand the fertilizer requirements of pasture and crops and, if a service is available, soil samples from the fields should be taken and analyzed. Potash, phosphate, and lime, if considered necessary, should be applied before planting, and nitrogen soon after planting (Williamson and Payne, 1978).

Soil with a high organic matter normally holds water better than soils with low organic matter content. The availability of plant nutrient other than water depends on the inherent fertility of the soil and the rate at which nutrient in the soil become available to the plant.

In general, tropical soils are not inherently very fertile (Williamson and Payne, 1978). Grazed forage certainly requires less fertilizer than continuously-cut forages. Approximately 80% of the nitrogen, phosphorus, and potash consumed by animals are excreted (Smith, 1965).

7.3.2 Pastures

Pasture improvement will greatly reduce the cost of livestock production (Morrison, 1959). The principal objective in the management (Williamson and Payne, 1978) of both natural and planted forage should be to maintain, as far as possible, maximum productivity on a year-round basis of the more desirable forage availability from the livestock that consume them.

7.3.2.1 <u>Fertilizer application</u> - The response of tropical grasses to varying levels of nitrogen fertilizer has been studied extensively. Warmke *et al.*, (1952) concluded that the dry matter yields as high as 38 tons per acre yearly have been recorded when applying nitrogen fertilizer to the herbage. This is more than 4 times the maximum production obtained from temperate grasslands under the most favourable conditions (Little *et al.*, 1959).

Although the application of massive doses of nitrogen results in tremendous herbage yields, the most efficient production per unit of fertilizer is registered at lower rates, that is 200 to 400 lb of nitrogen-acre-year. Vicente-Chandler *et al.*, (1962), for example, found that at this level of fertilizer application the pounds of dry matter produced for each pound increment of nitrogen varied from 25 to 89 whereas, at higher levels the figures are generally under 10. On the other hand, the greatest efficiency of protein production usually occurs at a somewhat higher fertiliser application rate than the optimum for dry matter yield. Under conditions of simulated grazing, the yields of dry matter and crude protein were little affected by the number of applications of nitrogen fertilizer, however; four per year appeared to give optimum results (Hardison, 1968).

Figarella *et al.*, (1964) found that phosphorus fertilizer did increase the yield of Napier grass and the response was dependant upon soil type. However, many of the tropical herbages (Hardison, 1968) are lower in phosphorus and higher in crude fibre at all stages of maturity than are temperate grasses at comparable growth stages.

In general, the influence of fertilizer elements, other than nitrogen, on herbage composition has received little attention. The main effect of fertilization seems to be a highly significant increase in herbage yield (Hardison, 1968).

7.3.2.2 The use of legumes - The introduction of a legume appears to be the best approach towards improving vast areas of tropical grasslands (De Guzman, 1975). The inclusion of legumes in pastures, instead of growing grasses alone, is desirable for the following reasons (Pasture newsletter V, 1 (3, 4, 6), 1973);

(a) legumes in association with the appropriate bacteria in their roots fix nitrogen economically for the pastures. Legumes are known to contribute as much as 250kg nitrogen/ha/ha.

(b) legumes are more tolerant of drought and produce green feed even during the dry season when feed is scarce as most grasses are dominant in the dry season.

(c) legumes have higher protein and mineral contents and that improves the quality of feed compared with grass alone.

Warmke *et al.*, (1952) attempted to evaluate combinations of legumes with Napier grass. Such combinations significantly outyielded either grass or legume grown separately in total dry forage and total protein. The increases yields were attributed to a more efficient use of available soil, sunlight and moisture by the grass-legume mixtures. Much subsequent research confirms the results. However, Caro-Costas and Vicente-Chandler (1956) found that Napier grass growing alone had a higher crude protein content, and produced about twice as much, dry matter and protein, as did a mixture of Napier grass and legume. Strange (1960) demonstrated that the increased dry matter yield doubled the protein production of a grass sward when soil nutrients were not limiting, while Horrell (1964) recently reported that unfertilized grass/legume combinations outyielded grasses growing alone. Additional evidence to show the beneficial effects of growing grasses in association with legumes is provided by Fernando (1962) and Smith (1968). Both of these workers obtained higher yields of dry forage and protein from combinations as compared to grasses grown alone.

7.3.2.3 Grazing systems - In practice it has been found that once the pastures are established (De Guzman, 1975) it will carry, on average, about one animal unit to 0.6 ha on a year-round basis. Trials have shown that rotational grazing of grasses should be done at two to four week intervals, whereas yield and persistence of most tropical legumes is improved if grazed at 8 to 12 week intervals (De Guzman, 1975). Overgrazing through the season is one of the most common faults (Morrison, 1959) in pasture management. It not only reduces the yield but it also weakens and drives out the most desirable pasture plants.

In continuous grazing, it was found that while the grass is growing actively the cattle prefer it to the legume. They clip the tops of the grass, promoting new palatable grass growth and allowing the legumes to build up a bulk of feed for later use.

7.3.2.4 Supplemental irrigation - In cases where moisture (Hardison, 1968) is the only major limiting factor to herbage growth, supplemental irrigation may be effectively used to increase dry matter production. Experiment in humid-regions, usually increased the yields of pasturage by 30 to 40 per cent or more, except when the rainfall during the season was plentiful and well distributed (Autrey and Corniff, 1949). Holmes (1968) observed that when cows are underfed and are grazing pastures very intensively, their milk production is depressed compared with when the cow is allowed a generous ration. In an attempt to increase the cow's level of feeding, a large area of pasture was grazed resulting in a decrease in the length of the grazing rotation.

McMeekan (1960) reported that the per hectare production can be increased by the use of high stocking rates which results in more intensive grazing and complete utilization of pasture grown (Table 51).

TABLE 51: Effects of Stocking Rates

Milk fat produced (kg/cow)	154	180	184	192
(kg/ha)	448	517	456	
Pasture produced (kg DM/ha)	12220	12320	11300	13140

7.3.2.5 The Stock - The production of herbage exhibits a seasonal pattern due in large measure to fluctuations in rainfall and this seasonal supply is reflected (Hardison, 1968) in animal performance.

Weight gains of heifers grazed on a pasture on a pure stand of grass and a grass/legume mixture amounted to 1.23, 0.83, and 0.08 lb per day for the wet, semi-dry and dry season, respectively in Nigeria (Motta, 1953). These results agree with more recent Nigerian work (Holmes and Jones, 1964) showing that the optimum mean liveweight gains of ranch-reared cattle occurred during the early and mid-rains, while in some cases animals lost weight during the dry months. Dindard and Allen (1963) have found that the weight gains of dry cows on pasture were not correlated with rainfall. Rivera-Brenes (1947) found that dairy heifers grazing unfertilized guinea grass pasture gave an average annual gain of 341 lb per acre over a 4-year period. The addition of 200 and 400 lb of nitrogen per acre per year increased gains to 530 and 794 lb per acre yearly, respectively.

In summation, it seems that the greater the amount of pasture offered to cows, the more pasture they will eat, and although the residue on the pasture will be increased, cow production will increase if cows are grazed laxly. Similarly, the use of high stocking rates per hectare will result in more of the available herbage being consumed.

7.4 Feed Supplementation

To obtain maximum productivity on range lands, (Williamson and Payne, 1978) some form of supplementation of the feed supply during the dry season is usually essential).

Supplementary feeding of dairy cows is necessary to promote milk production when the basic feed is limited in supply or if inferior quality.

7.4.1 Supplementation when grazing is not restricted

7.4.1.1 Concentrates - Many workers have found that when cows grazing ample pasture were given concentrates, a small increase in milk yield occurred (Wallace, 1957; Bryant *et al.*, 1961; Castle, 1963; Shepherd, 1962; Laird and Walker-Love, 1962). Wallace (1957) observed that cows fed 6 lb of concentrates daily during the initial 8 weeks of lactation increased their daily milk yield by 2.7 lb. Castle *et al.*, (1960) obtained an increase of 1.4 lb milk per day when 6 lb of meal containing bruised oats and flaked maize was fed to grazing cows.

The use of supplementary concentrates in most experiments had little effect on milk composition (Castle *et al.*, 1960;

Laird and Walker-Lover, 1962). However McClymont *et al.*, (1969) observed a decrease in butterfat percentage when young lush herbage was supplemented with concentrates. Other results have shown that concentrate supplementation may slightly increase both the butterfat and solids-not-fat (S.N.F.) percentage of the milk (Shepherd, 1962; Wood, 1966).

Holmes and Jones (1964) suggested that in most experiments, there was a decrease in herbage intake when concentrates were eaten, and this was the reason why there were only small increases in milk yield. Thus, the animals' total intake of digestible organic matter is only slightly altered. McLusky (1955) showed that when 7.3 lb of concentrates were given to grazing dairy cows there was a decrease of 2.8 lb of herbage dry matter intake. Thus the total intake of dry matter of the supplemented cows increased by only 4.5 lb. Seath *et al.*, (1959) found that 5.5 lb of grain meal given daily to grazing cows increased the total intake of dry matter intake by a mere 2.0 lb per head daily.

If the concentrates were eaten in addition to the herbage, instead of partly or completely substituting it, an increase in nutrient intake would occur. Therefore increases in animal production could be expected provided cows had not reached their full genetic potential to lactate with pasture alone. Unfortunately this is not the case when pasture is not restricted.

7.4.1.2 Roughage - There is little evidence to show that roughage feeds fed to cows have any beneficial effect on milk production when pasture is not restricted. Arnold and Holmes (1958) found that dairy cows grazing intensively-fertilized swards during September and October consumed 2.5 lb of straw daily, but this made no difference to milk yield or milk composition. Hutton and Parker (1966) showed that cows on a restricted grazing time of 20 hours and receiving a supplement of 3 lb hay per cow per day showed no significant difference in milk yield and milk composition from freely grazed cows. Similar results were obtained by Castle *et al.*, (1960); Cole *et al.*, 1957 and Seath *et al.*, 1959).

7.4.2 Supplementation when grazing is restricted

7.4.2.1 Concentrates - Hancock (1958) examined the effects of stocking rate and the feeding of concentrates on milk production of Jersey cows.

Monozygotic twins were used to compare three treatments in a continuous type of experimental design conducted over three years. The treatments were:

(i) concentrates at 1 lb per 5 lb of milk produced; stocking rate of 1 cow per acre,

(ii) no concentrates; stocking rate of 1 cow per acre,

(iii) no concentrates; stocking rates of 1 cow per 0.6 acres.

The results showed the importance of stocking rate in determining output per acre and increasing the utilization of grassland. The response to concentrates was 1 lb of extra milk per 0.8 lb of concentrates. Hancock (1958) attributed this to the consumption of concentrates in addition to other evidence; alternatively it seems possible that the cows which did not receive concentrates were under-fed in the critical periods of late pregnancy and early lactation and that this was responsible for the reduction in milk yield.

Castle (1967); Holmes *et al.*, (1966); Holmes and Curran (1967) have confirmed the dominant effect of stocking rate in achieving a high output of milk per acre. At a stocking rate of 1.7 cows per acre in 1964, a response of 4.1 lb of milk per

3.3 lb of barley was obtained and in 1965, at a higher stocking rate the response was 6.6 lb of milk per 3 lb of barley. Leaver *et al.*, (1967) found that cows stocked at 2.4 per acre and receiving supplements reduced their intake of herbage organic matter (O.M.) so that the effective increase in feed intake was only half that of the concentrate offered.

Thus, where there is a scarcity of herbage, or herbage of low quality, restricting nutrient intake to levels below those required for production, then a response to supplementation can be anticipated.

7.4.2.2 Roughages - Hutton and Parker (1966) restricted the grazing time of cows to four or eight hours per day and offered hay *ad libitum*. Cows grazing eight hours ate 9 lb of hay and those grazing for four hours ate considerably more. They found that hay significantly increased milk yield and slightly reduced butterfat percentage. Otherwise little research has been done on the effect of supplementary roughage to dairy cows on restricted pasture intake.

Supplementary feeding when cows are fed pasture as a basic forage is necessary only when herbage is scarce and cannot support milk production of the grazing stock. Supplementation used over this period can help situations of high stocking rates and high output per acre.

7.5 Summary

The production of livestock is largely dependant on the herbage that the animal grazes. In tropical climates, as has been noted, different grasses have different compositions. Stages of growth of forages, soil fertility effects and climatic effects, greatly affect herbage composition and production.

Furthermore, the intake of grazing animal depends on variable factors associated with the feed, management and intrinsic aspects of the animal itself. Good management of animals and swards will surely tend to increase animal feed intake. Generally, the production of forages in tropical climate is very low compared with those in temperate climates. This is attributed in general to poor soil, low digestibility of grasses, and mismanagement of pasture. It is therefore necessary to improve pasturage, and eventually to increase feed intake by animals, through application of fertilizers, introduction of legumes, and providing supplemental irrigation. Supplementation of animal diets is very important to meet the sequential physiological body requirements of stock because of the low composition and digestibility of tropical grasses.

CHAPTER VIII

DISEASE FACTORS LIMITING PRODUCTION IN THE TROPICS

Profitable animal production demands efficient husbandry of healthy animals, and disease remains a profit-limiting factor in most tropical territories. Even in countries where there is intensive veterinary control (Lindley, 1978), disease may cause losses of between 15 and 20 per cent of the total production. The importance of diseases as a limiting factor in milk production may be highlighted by the problem of calf diseases (Payne, 1974) where mortality as high as 5 per cent may be considered "acceptable" and even 10 per cent bieng "not unusual". The Ministry of Agriculture Calf Wastage Survey (Leech *et al.*, 1968) recorded losses of between 5 and 6 per cent in the first 10 days of life. Some estimates suggest losses of calves at 260, annually in Australia. Important though this may be wastage of calves is not the only source of loss of stock; there are also diseases of dairy cattle to be taken into account.

Payne (1957) stated that the incidence of both temperate and tropical disease varies widely from country to country. Disease is not however, a prohibiting factor in most tropical countries like Northern Australia, Pacific Islands, some islands in the East Indies, and the southern part of North America. Disease is widespread in many parts of Africa and Southeast Asia but is being gradually brought under control and at present only partially limits production in most territories. Conditions are ideal for the growth and spread of internal parasites in all parts of the humid tropics, but they can be controlled by a combination of good husbandry and the judicious use of drugs.

The failure of western dairy breeds to thrive in the Philippines (Rigor, 1967) can be attributed in part to the ravages of tropical diseases. Because of their origin in temperate climates, some exotic cattle cannot stand the attacks of tropical diseases which frequently occur under the hot and humid regions. However, with the efficient vaccines now available, few animal diseases should present insurmountable problems in animal production projects.

Of course, low production may also be the combined result of the effect of climate on cattle, low plane of nutrition and poor management. However, good husbandry and continuous medication can often reduce the effects of disease and parasitism.

8.1 Disease of cattle found in the Philippines

The general disease situation in Asia (Eusebio, 1967) is under control, but there are diseases which causes periodic losses. Sporadic cases of foot and mouth disease, haemorrhagic septicaemia and anthrax have been reported. Liver fluke infestation is a disease of major economic importance, particularly with water buffaloes.

In the survey by Rigor (1967) of the dairy industry in the Philippines, it appears that the most troublesome diseases are: sterility, abortion, tuberculosis, udder trouble, Texas fever, anaplasmosis and foot and mouth. Parasites, both external and internal are causing untold havoc to dairy animals, especially to calves. Piroplasmosis, anaplasmosis, stomach worms and liver fluke are very serious parasites of dairy cattle in the Philippines.

8.2 Diseases of dairy cattle in the tropics that affect reproduction

McDowell (1972) stated that diseases of the reproductive tract frequently reduce fertility, or create temporary and even permanent infertility. The most common are brucellosis, vibriosis, trichomoniasis and leptospirosis. Of these, brucellosis is most prevalent and damaging, in that abortion rates may be high in an infected herd. The other diseases can also cause abortion or reduce fertility. Strict control and testing programmes are the only means of decreasing reproductive diseases. Some such as brucellosis can be controlled by vaccination. Trichomoniasis and vibriosis usually respond to antibiotics, but seriously affected animals should be removed from the herd.

Reproduction is affected indirectly by the general system diseases (Rathore *et al.*, 1972) which interfere with the well-being of the animal. Some specific diseases, transmitted from the animal system by physical contact at mating, or through the semen, interfere with reproduction because they tend to localize, at least in part, in the reproductive tract.

McTackett (1963) reported that brucellosis was the most common cause of outbreaks of abortion in dairy herds in United States. Burnside *et al.*,(1971) reported that in Canada 0.9 per cent of cows were culled because of brucellosis infection alone. Losses occur through forced culling, decreased production, and abortion of foetuses. Hungerford (1970) states annual loss in calf drop in New South Wales as result of brucellosis is approximately 15 per cent. McLure and Dowell (1969) reported the loss of production due to increased length of calving interval in 1,302 brucellosis-positive cows was equivalent to

9,114 lactation days. Extrapolated to the 1971 (Bur. Ag. Ec. 1972) cow population in Australia this loss could be equivalent to over nineteen million lactation days.

Vibriosis or vibrionic abortion is caused by an organism and infected bulls show no physical signs but can pass the disease to cows at mating or through semen under artificial insemination unless antibiotics are added to diluted semen. Healy (1962) reported that vibriosis was responsible for 61 per cent of infertility in 93 problem herds on the northern coast of New South Wales. A New South Wales Department of Agriculture Survey (1963) revealed that 23.8 per cent of beef cows had vibriosis and an abortion rate of 7 per cent. Moore (1954) stated that bovine endometritis was involved in 85 per cent of infertility cases, and thus was one of the most important entities in the entire field of veterinary practice. Vibriosis causes abortion, temporary and permanent sterility and disorganization of breeding programmes (Rathore, *et al.*, 1972). This results in heavy economic losses as cows are out of production for a long period and repeatedly return to service. The extent of loss varies with the degree of infection.

Trichomoniasis like vibriosis is venereal in nature, but is caused by a protozoan parasite, *Trichomonas foetus*. This disease commonly results (Rathore *et al.*, 1972) in herd infertility characterized by an early termination of pregnancy and a return to oestrus some five or six weeks following service. A small number of abortions may be recognized between the third and fifth month of pregnancy but this is not common. Return to oestrus is usually accompanied by a mild metritis in the early stages with varying amounts of pus clouding the mucous discharge. After the initial infection, there is a degree of local immunity.

If early death of the foetus does not result in is expulsion and the cervical seal remains intact, pyometra results with the accumulation of thin, greyish-white to yellow, flocculant non-odorous fluid in the uterus.

Leptospirosis is caused by an organism, *Leptospira pomona* which causes high fever and affects the kidneys, and pregnant animals often abort. A decrease in milk production is typical. Some cows completely dried off. Although short abortion is the most common symptom recorded, the high incidence of icterohaemoglobinua (red water) in calves in infected herds indicates that calf wastage may be the major economic loss. The economic effect varies from generation to generation and an assessment of the annual economic loss is not easy to assess (Rathore *et al.*, 1972).

8.3 Diseases of dairy cattle in the tropics that lower milk and eventually change its milk composition

So far only mastitis and ketosis are known to affect milk composition as well as yield of milk.

Mastitis is considered the most prevalent and costly dairy cattle disease. Milk from those cows with mild clinical mastitis has decreased percentage or total solids, fat and non-fatty solids particularly lactose. At least twenty different types of bacteria can cause mastitis which is referred to technically, as infectious, have shown losses in milk production and changes in milk composition due to this disease. In a comprehensive review of literature, Hanses (1970) reported an estimate percentage total milk production losses of 5 to 25 per cent. Quarters with California mastitis test (CMT) reaction of "3" produced 2.7 kg per day less milk than the oppositve negative quarter.

Major decreases in percentage of fat, solids-not-fat, lactose and total solids have been reported (Notzke, 1970). More recently Marx L971) reported from 16 cows that infected quarters produced 20.3 per cent less milk than uninfected quarters. An additional loss of 1.5 per cent occurred if the infected quarter required therapy.

Ketosis, also known as acetonaemia, is a metabolic disease associated with failure to effect complete combustion of carbohydrates and volatile fatty acids in the food with a consequent accumulation of ketones in the blood, urine, milk and tissues. This occurs mainly in dairy cows. Belshner (1967) records that the rapid loss of bodyweight in affected animals is greater than would be expected from the decrease in appetite and agrees with Sampson (1955) that milk production may be reduced to half the normal amount secreted, or still less if the cow refuses all food. Shaw (1955) estimated that the loss of $10 million per annum to the dairy industry in U.S.A. Blackburn (1958) calculated that, on average, there was a loss of 15 per cent of milk yield in the early part of lactation due to this condition. Youdan and King (1977) found that the number of days from calving to maximum weight loss was 65 days and the average bodyweight loss was 9.6 per cent of the first recorded weight after calving. The percentage drop in weight of 11.91 over the relatively short period of illness was obviously greater than would have occurred in healthy cows (King, 1969). The significant drop in milk yield of 25.82 per cent does not show the true extent of milk loss.

8.4 Prevalent diseases of dairy cattle in the tropics

Foot and mouth disease, liver fluke, anthrax, haemorrhagic septicaemia, infectious foot rot, tuberculosis, tetanus, brucellosis, mastitis and worms are the most common diseases affecting dairy cattle under Philippine conditions.

Others which are less common but which affect the dairy herd are: anaplasmosis, coccidiosis, trichomoniasis, tick, fly, lice, nematodes and blackleg.

Most diseases of a general nature influence the rate at which milk is secreted or the composition of the milk. As the amount of milk decreases, sometimes the percentage composition of constituents increases, as can, to a slight degree, most of the solids other than lactose. Although the total nitrogen may increase the, casein decreases; the albumen, the proteose-peptones, and particularly the globulin increases (Rowland, 1938). Factors not easily analyzed for, such as the various non-protein nitrogen factors, enzymes, etc. may also vary (Anderson, 1969).

Diseases of the udder, such as mastitis, usually cause an increase in chloride and a decrease in the lactose content of the milk (Bryan and Trout, 1935). There is also a shift toward a more alkaline reaction in most instances, probably due to the greater permeability of the cell walls to the bicarbonates. The increase in alkalinity is the basis for the bromthymol blue test for mastitis. Normal milk with a pH of 6.7 turns greenish yellow when the indicator is added, but milk with a pH above 7.0 has a dark-green or blue-green colour upon the addition of the indicator (Espe, 1941). Abnormal milk has lost certain germicidal properties possessed by normal milk while in the udder and for a short time after it is drawn (Hunzicker, 1901).

Table 52 shows the basic information concerning infectious diseases of cattle and buffalo prevalent in the tropics (Williamson and Payne, 1978).

8.5 Diseases of buffaloes in the tropics

Commonly occurring viral, bacterial and parasitic diseases of the buffalo are much the same as those of cattle. However, the susceptibility of buffaloes and cattle differ (Williamson and Payne, 1978) in relation to several of these diseases.

It has been observed that buffaloes are less susceptible than cattle to foot and mouth disease. Haemorrhagic septicaemia (pasteurellosis) appears to run a more acute course in buffaloes than in cattle, and the oedematous form is more common. Lall *et al.*, (1969) reported that the buffalo is relatively resistant to tuberculosis. Mastitis is one of the serious diseases of the buffalo, especially when kept for milk production. A mastitis survey carried out on 690 buffaloes in nine dairy herds in different parts of India showed an incidence of 20.7 per cent of sub-clinical cases, and 2.4 per cent of clinical cases (Williamson and Payne, 1978). Brucellosis is fairly common in buffaloes. In a survey of 13,565 animals in military dairy farms in India, 10 per cent of the buffaloes and 13 per cent of the cows were found to be positive reactors on serological tests (Mohan, 1968). Heavy mortality in buffalo calves due to coccidiosis has been reported from India and Sri Lanka (Mohan, 1968). Fascioliasis is another important disease of buffaloes, where in a survey in Thailand, 7 per cent of 29,421 buffalo livers were found to be cirrhotic due to fluke infestation. Buffalo appear to be less affected by ticks than cattle (Mohan, 1968) and warble infestation is also less prevalent in buffalo

TABLE 52: Basic information concerning some infectious diseases of domestic livestock prevalent in the tropics

Disease	Transmission	Incubation period	First symptoms	Animals affected	Preventive measures
Blackquarter	Water and food contaminated with blood and excretions or by wound infection	2 to 5 days	Gas gangrene. sudden death	Cattle and sheep	Annual vaccination
Contagious bovine abortion	Food, water, etc., contaminated by discharge and aborted foetus	7 days to several months	Abortions, full-term stillbirths, retained afterbirths.	Cattle and buffaloes	Segregation and other sanitary measures. Vaccination before breeding.
Contagious bovine pleuro-pneumonia	Direct contact.	2 weeks to 4 months	Frequent painful subdued cough. Prolonged unthriftiness	Cattle	Annual vaccination slaughter of animals
East Coast fever	Infective ticks	1 to 4 weeks	High fever, unthriftiness, weakness	Cattle. Sometimes buffaloes in East Africa. Cattle indigenous to enzootic areas are immune.	Tick control and elimination
Foot and mouth disease	Direct contact or with material contaminated with discharge from lesion	3 to 8 days	Salivation, vesicles on tongue and feet, lameness, fever	All dosmestic animals	Segregation and other sanitary measures. Vaccination.
Anthrax	Water and food contamination with blood and excretions or by wound infection	1 to 3 days or longer	Sudden death or very high fever	Mostly cattle. Buffaloes, sheep, goats, pigs and horses less frequently	Annual vaccination.
Rinderpest	Direct contact or with material contaminated with discharge from lesions	3 to 15 days	High fever, blood-stained diarrhoea, mouth lesions	Cattle, buffaloes. Sometimes sheep and goats	Vaccination

cntd

TABLE 52: cntd

Disease	Transmission	Incubation period	First symptoms	Animals affected	Preventive measures
Piroplasmosis (Babesiosis)	Infective ticks	1 to 4 weeks	Fever, red urine, progressive weakness	All domestic animals	Tick control and elimination
Heatwater	Infective ticks	9 to 28 days	Fever, nervous signs, convulsions	Sheep, goats and cattle	Tick control and elimination
Trypanosomiasis (surra, nagana, etc.)	Tsetse and other infective flies	Few days to some weeks	Intermittent fever, unthriftiness	All domestic animals	Chemoprophylaxis and fly eradication

(Sen and Flecher, 1972).

8.6 Prevention and Control

The ideal, for maintenance of health, is to keep animals in small herds segregated on non-contaminated grounds, in clean accommodation, watered and fed apart from other stock and kept free of external and internal parasites. The first essential is to recognize all aspects of the sound animal-healthy eyes, skin, membranes, excretions, discharges (Williamson and Payne, 1978).

First sign of disease may be obscure and often it is only when there is radical change in behaviour, or drop in production, that suspicions are aroused. A consequence of some infections is that animals show a rise in body temperature, usually accompanied by other disturbances such as inappetence and shivering which indicate the presence of fever. Laboratory examination of material from sick or dead animals may be necessary in order to make a diagnosis.

The actual mechanics of the application of sanitary control must depend upon local circumstances and the disease suspected. The quicker the control measures are implemented the more successful they are likely to be. Necessary vaccination and treatments of the various groups of stocks should be initiated, and as these measures may have to be continued for several weeks, division and segregation of the herd may sometimes require the employment of additional labour for feeding and herding until all risk of spread of infection has passed.

In conclusion, profitable animal production demands good husbandry with a positive endeavour to maintain health. To achieve this the farmer should be vigilant for early signs of disease and inculcate similar awareness in his companions.

Furthermore, an animal which is well-fed and watered and in good condition will resist disease better than one that is undernourished or suffering from deficiency, climatic stress or parasitic infestation. Good management can do much to remove or reduce the effects of environmental factors which sometimes can cause a disease.

CHAPTER IX

HERD MANAGEMENT PROBLEMS

The most urgent and immediate need (Miller, 1968) is to raise the productivity of any dairy industry in a co-ordinated educational effect put into the basic practices of feeding, breeding and management. A basic aim of good management in the tropics (Payne, 1955) is to take all economically justified measures that will decrease the "heat load" on the stock or help "spread" the "heat load" more evenly over the twenty-four hours of the day. Thus it is imperative that in all tropical countries management studies to this end should be actively pursued. It is almost certain that the productivity of dairy cattle everywhere in the tropics can be raised immediately by improved management (Payne, 1957).

Pino (1968) pointed out that losses in potential productivity in cattle herds were mainly attributable to poor mating management (50% calving rate per annum), death losses from birth to weaning (15%), mortality from weaning to market age (5%), and losses from poor growth (30%). Most of those losses are due to lack of close attention to the animals.

9.1 Management problems at calving

Zablan *et al.*, (1964) noted that about 89 per cent of cows gave birth in open pastures and only 20 per cent in sheds and corrals under Philippine conditions. From the standpoint of good management (Williamson and Payne, 1978) there is a need for an attendant during calving time so that assistance is available if necessary. Feeding the calf with the first milk ("colostrum"), which contains antibodies to provide some immunity to bacterial diseases, is usually carried on. Ordinarily, the colostrum should be fed for the first 3 to 4 days, or until the milk becomes normal (Henderson, 1971).

There is a great variation in practice regarding the time at which the calf is removed from the dam. Some take the calf away at once without allowing it to suckle; others allow it to suckle the dam three to four days. However, it makes little difference as to when the calf is removed from its dam, provided the calf has had at least one drink of colostrum milk. An advantage of removing the calf early is that the calf is taught to drink more easily from pails.

9.2 Rearing young stock

According to Payne (1968) where the management of grazing cattle is good, dairy calves in the tropics grow most rapidly when managed on an indoor-outdoor system, (Table 53); that is, outdoors at night and indoors during the day time. Under this system, the calves receive considerable protection from climatic stress, and it had been found that because the larvae of most internal parasites are phototropic they are more likely to be ingested by calves during daylight grazing than during grazing at night when the parasite larvae move down the stems of the forage towards the soil (Williamson and Payne, 1978).

Philippine data showed that the growth rate of calves was significantly better in the drenched, indoor-outdoor management group. Calf mortality in the tropics is undoubtedly very high, often as high as 50 per cent which almost invariably denotes bad stock management and climatic stress (Williamson and Payne, 1978).

TABLE 53: Effect of management and drenching with a vermifuge on liveweight gain and mortality in dairy calves at Los Banos, Philippines

Group	No. calves	Liveweight gain (kg per day)	Percentage total mortality
I Indoor management	28	0.344	3.6
Drenched	15	0.385	6.7
Undrenched	13	0.300	nil
II Indoor-outdoor management	23	0.404	8.7
Drenched	10	0.435	10.0
Undrenched	13	0.380	7.7
III Outdoor management	27	0.387	29.6
Drenched	12	0.403	16.7
Undrenched	15	0.369	40.0

Notes: (1) The calves were mixed Sindhi x Friesian crossbreds and high-grade Friesian
(2) The experimental period was from 13 to 52 weeks of age.
(3) Calves were selected for the groups at random.
(4) Thiabenzole, phenothiazine and promintic were used alternatively as vermifuges for two-thirds of the experiment; during the latter third only thiabenzole was used. Drenching was at 14-day intervals.

McDowell (1972) stated that the length of time to weaning is dependent upon the breed, season and month of birth. Calves should weigh at least 140-160 kg or approximately 30 per cent of mature body weight before being made dependent on grazing alone. In contrast, in New Zealand, the target weights reported to be desirable in practice are shown in TAble 54 (Bryant, 1970). However, in New Zealand levels of feeding during rearing are relatively good, and young stock are reared on prasture alone from about eight weeks of age.

On the average, the maximum weight of calves at birth is produced by cows between 3rd and 6th calving.

Late calving is common in tropical countries because of stress and because of pasture quality and supply problems. The time of calving is not clearly related to the onset of pasture

TABLE 54: New Zealand Data on Weight of Jersey and Friesian Young Stock

	Jersey	Friesian
Birth	25 kg	35 kg
Weaning (2 months)	50 kg	70 kg
Mating (15 months)	200 kg	280 kg
Calving (24 months)	320 kg	410 kg

growth but is usually carried out throughout the year, regardless whether it is the dry or the rainy season.

9.3 Rearing young heifers

The aim in rearing heifers should be to achieve the maximum growth and development at the earliest sexual maturity consistent with least cost (Williamson and Payne, 1978).

If yearling heifers are fed 0.25 kg per head per day of concentrates, in addition to available pasture, their liveweight will improve and the time taken to attain sexual maturity will be reduced. Hancock and Payne (1955) stated that the grazing management practice is still the major factor affecting the growth rate of heifers. Experimental work in New Zealand has shown that rotationally-grazed heifers can weight 68 kg more than set-stocked animals at 20 months of age. Table 55 shows the feeding standards for heifers as recommended in the U.S.A.

The age at which heifers should be bred depends upon several factors. In studies at the Missouri Station (1915), it was found that whereas gestation in itself did not affect the rate of growth to any great extent, the subsequent lactation had a decided influence upon growth rate. Heifers during lactation did not grow nearly as fast as did unbred or pregnant heifers of the same age and breed.

TABLE 55: Feeding standards for heifers. Daily nutrient requirements

Liveweight* (kg)	Feed intake† (kg)	TDN (kg)	Protein (kg)	Ca	P
150	3.6-4.4	2.3-2.8	0.43-0.53	12	11
200	4.8-5.6	2.9-3.4	0.47-0.57	13	12
250	5.8-6.6	3.3-3.8	0.57-0.69	14	13
300	6.8-7.6	3.8-4.3	0.59-0.75	15	14

* It is assumed that the growth rate during this period will be at a maximum

† Based on air-dried not dry-matter content. Intake data must vary according to the composition of the ration and climatic environment.

Source: National Academy of Sciences - National Research Council (1966)

The majority of heifers in the tropics are too small, and hence too sexually immature, to breed at any early age and, normally, first service does not take place until they are much older than 15 to 18 months. It is therefore recommended that liveweight rather than age should be used as criteria as to when heifers should be first bred. Adequate liveweight would be 200-225 kg for the small breeds, and 290-315 kg for the larger breeds (Payne, 1968).

Bryant (1970) stated that adequate preparation of the cow for lactation is essential for subsequent high levels of milk production. This involves the provision of sufficient feed to meet the demands of (1) daily maintenance, (2) the developing calf, and (3) the cow having sufficient energy reserves in the form of body fat for use in early lactation. Furthermore, he enumerated guides to adequate preparation, as follows:

(1) Assessing feed intake - Dry matter intake should increase to maintain liveweight and to meet the demands of the foetus at an increasing rate. From 4-5 kg pasture intake per cow daily prior to calving, to 6-8 kg dry matter

at calving, is an adequate ration.

(2) Cow liveweight - An extra 4-5 kg of dry matter is required to increase body weight by 1 kg. The factors which determine calving-down weights are (a) drying-off weight, (b) available feed supplies, and (c) length of the dry period.

(3) Cow condition - This is very important because it is the measure that is independent of the size of the cow or gut fill. It also serves as guide for feeding adjustment.

9.4 Milking cows and associated problems

The object of efficient milking is to obtain the maximum quantity of milk from the udder. Before milking is commenced, the udder should be properly washed and, if necessary, the abdomen and legs of the animal thoroughly washed too. Under tropical conditions, the animal is customarily placed in a night corral which is not completely cemented, and sometimes the soil is very muddy so that in the following morning cleaning the milking cows and buffaloes is a problem. However, it is always the habit of the dairy farmer to clean or wash the animal prior to milking.

In milking, there are importance practices to be followed, as stated by Payne (1968a). The first essential in milking technique is to prevent the animal becoming excited or frightened, and to milk quickly and completely. This applies to all animals, whether milked by hand or by machine. The let-down of milk is enhanced by stimulation of the udder by washing and by action of the teat cups of a milking machine. Once the stimulus is established, the nervous system relays a message to the posterior pituitary gland which releases the hormone known as oxytocin.

This hormone circulates in the blood, is carried to the udder tissue and then initiates the let-down process. As the hormone is in circulation for only a short period (4-5 minutes), the more quickly milking is carried the more efficient it will be. With both hand and machine milking, the establishment of a strong let-down stimulus is an essential part of the preliminaries of milking. Another hormone concerned with milking is adrenalin. This hormone is involuntarily secreted when the animal is excited or any way disturbed during the milking process, and the effect is for the milk let-down to be suspended.

9.4.1 Hand versus machine-milking

Payne (1968a) stated that machine milking is not quite so efficient as the best hand milking, but that it is generally superior to average hand milking.

Nevertheless, machine milking is likely to be introduced when labour is scarce and expensive, if machines are available; labour dislikes the toil of hand milking, and if a sufficient number of cows is milked to justify the installation of a machine, this device can be a great advantage.

None of these criteria apply on small dairy farms in most tropical countries. Payne (1969) further stated that there is usually a surplus of labour which is often cheap, and the average size of the herd in the tropics is commonly quite small.

9.4.2 Frequency of milking

Cows are usually milked twice daily at approximately 12 hour intervals. However, in some parts of the tropics, milking is usually carried out only once daily, that is every morning, especially during summer months. The reason for this practice is that feed supplies are limited over the summer months, and so milk yields are low and all livestock are very thin. If feed supplies could be improved, twice-daily milking would be recommended.

In experimental work in Australia and New Zealand (Payne, 1968b), it has been shown that there is no significant change in the average hourly secretion of milk by cows varied from equal 12-hour intervals to 16 and 8 hour milking intervals, respectively. High-producing cows may with advantage be milked more frequently than twice daily, and three times a day milking may increase total milk production by approximately 10 per cent. The increased production is not due to the cow exhibiting high per hour secretion rates, but due to other factors. Possibly the more frequent milking leading to a greater total release of galactopietic hormones from the anterior pituitary gland.

9.4.3 Buffaloes versus cows at milking time

Since some of the tropical countries have not acquired specialised dairy breeds because of reasons such as shortages of capital to purchase stock and poor adaptability of such stock, buffaloes are on occasions the prime animals to be milked. In comparison with dairy cows, the buffalo seem to be easy to handle and to milk. This may well be attributed to the frequent handling of the buffaloes on the farm where they are commonly used for draft purposes.

9.5 Detection of oestrus

Dairy cows usually come into heat 30 to 60 days after calving (Payne, 1968b). In the tropics the most suitable practice would appear to be breed the cow at her first heat period after calving, and certainly not later than 60 days after calving.

Payne (1968b) also remarked that the chances of conception at first service are less in the tropics than in temperate areas.

Then, a small percentage of heifers and cows is, of course, always infertile in all herds. The incidence of sterility in females in tropical stock up to 10 years of age varies from 3 to 5 per cent (Payne, 1968b) although, when they are older than 10 years of age, the percentage rises rapidly.

The duration of heat is usually between 18 to 24 hours but, in the case of heifers, is a few hours shorter (Payne, 1968b). In addition, the short heat period often occurs at night and "silent" heats are common.

Heat detection may be improved by the use of vasectomized bulls equipped with a head stall, managed with heifers and cows. The bulls will mark female stock coming in heat. Other heat-detection equipment may also be used including phials of dye attached to the back of the female that burst when she is mounted, either by another female or by a vasectomized bull (Payne, 1968b). Alternatively, heat detection could involve the use of a strip of enamel paint over the tailhead of the animal. On being mounted by other cows, the paint strip on the cow in season will be broken, and so oestrus diagnosed.

Errors in heat detection will become more marked as herd size increases. It is therefore important to recognize signs that the cow that is "in-heat" as summarized by the Farm Production Division of the New Zealand Dairy Board, to wit:

(1) normally a cow will not freely stand to be mounted unless she is on heat.

(2) swelling and redness of the vulva accompanied by the discharge of a string of clear mucous

(3) cows become irritable

(4) cows tend to group together

(5) fresh abrasions on the root of the tail and streaks of

mud on the flank, from the chest and feet of a mounting cow.

Correctly used, vasectomized bulls with marker harnesses will identify most cows in heat.

9.6 <u>Mating management in relation to ovulation</u>

Mating at the correct date is dependent upon the onset of oestrus. The correct timing of service within the oestrus period is decided by the cow under natural mating conditions, but with artificial insemination it becomes the farmer's responsibility. According to Dunford and Stichbury (1972) insemination of cows in the latter part of oestrus, and heifers a little earlier, achieves best conception rates.

Allowing the bull to run with the herd requires least effort but it introduces uncertainty into the breeding programme of any herd; this is known as "paddock mating". This is usually the practice in many tropical countries but paddock mating is inefficient and generally is characteristic of a thoroughly disorganized farm practice (Lamond, 1961). Ashton *et al.*, (1956) further stated that it can lead to more late calving cows and a loss of production as a result.

In the case of artificial mating, the risk of disruption to the calving pattern is reduced by the use of several bulls. James (1958) stated that artificial service eliminates any risk of using a sterile bull, or a bull with low fertility.

Palad (1976) stated that the duration of mating season is a basic factor in determining management. The shorter the season, the greater will be the stress on the herd bulls; in other words, there must be an adequate supply of bulls for a good management system to lead to a maximum herd milk yield over a reasonable length of time.

In the Philippines, Zablan *et al.*, (1964) stated that 98 per cent of farmers breed their cows naturally. The reason for this is a lack of "know-how" and of facilities in regard to the use of artificial insemination. Table 56 shows the comparative conception rates for artificially and for natural service herds from Dale and Smith (1968).

TABLE 56: Comparative conception rates for artificial and natural service

Descriptions	A.B. herds	Natural herds
Total no. of animals	3443	2489
Conception rates (1st service)	61.6%	65.8%
Conception rate (1st & 2nd Service)	81.1%	83.6%
Animals failing to conceive	6.9%	8.6%
Abortion rate	2.1%	2.8%
Calves dead at birth	3.0%	2.6%
Twinning rate	1.8%	2.6%
Live calf production	89.9%	86.7%

In New Zealand, non-return rates of almost 67 per cent are achieved with all three of the following practises:

(1) artificial breeding with "variable temperature" semen,

(2) artificial breeding with deep frozen semen, and

(3) by natural service (Hollard, 1979a).

9.7 Other management problems

Good identification is the key to livestock improvement, without which any breeding programme will fail. The system of identification must, however, include accurate records. Reading an ear tag or tattoo has no value unless one can refer back and obtain information on the animal's ancestry (Dairy Exporter

Supplement).

In the same manner, sound management with milking stock involves keeping records (Lindstrom, 1976). Milk recording data is complementary to data on reproductive performance in formulating breeding programmes.

In tropical countries, the major problems concerning record-keeping and identification is lack of funds which affect the following:

(1) low education standard of farmers;

(2) lack of qualified extension workers;

(3) few incentives for farmers to record their cows;

(4) small average size of herds;

(5) poor communications;

(6) unrecognized need for progeny testing;

(7) poor data collection and processing facilities.

It is difficult to develop extensive milk recording services (Lindstrom, 1976) if the government does not actively promote them.

9.8 Feeding systems

Adequate feeding of both young and mature dairy stock is still a basic problem in many tropical countries and indeed in temperate areas too. Clear appreciation of the feed requirements for all classes of stock is required and a knowledge and application of economic methods of satisfying these requirements is necessary if milk production is to be expanded in an efficient manner.

It is true that difficult environmental conditions in tropical areas make it more to achieve the ideals in dairy stock nutrition compared with the case in temperate areas. Nevertheless, for progress to be made, the basic principles of nutrition have to be applied within the limits of economic discretion.

The maintenance requirement of a cow will be greater (Greenhalgh, 1969) when it is lactating and is fully-fed than when it is fasting or fed at a non-production level. In high-producing cows, requirements for nutrients may be large in relation to the size of the animal. As a general rule the maximum daily intake of cows does not exceed 3.5 per cent of liveweight. Food intake in cattle is obviously related to body size and to the milk yield. In general, soon after calving, lactating cows eat 40 to 50 per cent more dry matter per day than dry cows (Hutton, 1963; Holmes *et al.*, 1965).

Feeding cows in the dry period (Broster, 1971) is important in increasing the cow's body condition. This is necessary for the body fat to be mobilised in early lactation. Campbell and Flux (1948) advocated that "steaming-up" of dairy cows immediately before calving is essential for maximal or highest peak in milk production in early lactation. They had pointed out that a loss of 40 kg liveweight per head in late pregnancy will be attained if giving the cow a low plane of nutrition. Whereas, feeding on a high level of nu-rition in late pregnancy will increase the body weight of mature Jersey cows at calving to an average of 450 kg at Ruakura (Less *et al.*, 1948) and the body weight of two-year-old Jersey heifers to 280 kg at Palmerston North, both in New Zealand. Reasons for the desired high plane of nutrition before calving includes the provision of energy reserve in body fat and the stimulation of udder tissue development. In conclusion more food in late pregnancy leads to greater liveweight gain in the dry period and to greater liveweight losses in early lactation (Broster, 1971); hence a greater milk yield in early lactation accompanies greater loss of liveweight in early lactation can be expected.

During the early part of lactation, the body reserves must be adequate to cover (Broster and Clough, 1976) the critical early weeks of lactation. Hence, the ability to draw on body reserves is a major factor for the high yielding cow (Broster, 1976). At this period, it is the time when the cow's current yield is sensitive to increased intake. For a change in peak yield of one litre per day, the total lactation yield will be increased by 150 to 220 litres. The performance level peak of milk yield is due to the direction of nutrients of milk (Broster, 1976) at the expense of deposition of body reserves in mid- and late lactation following development of full yield capacity. Dry matter intake is very low at early part of lactation because the cow utilises her body reserves for peak milk yield. In other words, it offsets the undernutrition caused by low voluntary feed intake. Broster, (1976) stated that the efficiency of milk production is equal to the efficiency of body gain in lactating cows at about 65 per cent for metabolizable energy intake. Efficiency of conversion of body fat to milk is estimated at 85 per cent. Unfortunately there are problems (Broster, 1976) of obtaining maximum yield with digestion problems from over-loading the ration with concentrates, low food intake capacity after calving, ketosis from excessive heavy demands on body reserves, difficult calving, and possible vitamin A deficiency.

During the second and third month of lactation (Broster and Clough 1976) is the period considered as "peak yield" of cows. However, at mid-lactation, a cow will settle to its natural rate of decline in milk yield and body reserves will accumulate. The intake of dry matter by milking cows (Hollard, 1979) will vary during lactation, a peak of about 3.5 to 4% of liveweight is reached on an all-grass ration (12 MJ/kg DM) some 12 weeks after calving, and the decline is slow about 2.75 per cent at 20 weeks, and 2.2% at 28 weeks after calving. In conclusion, milk yield decreases during the mid and late lactation gradually but intake of dry matter increases considerably. This large intake of dry matter at the end of lactation is converted efficiently to body fat and provides an important energy reserve.

Food intake in cows depends, of course on characteristics of the feed as well as characteristics of animals (Balch and Campling, 1962). It is now well-established that ruminant animals eat less food which is low in digestibility than they do of more digestible material (Blaxter *et al.*, 1961; Blaxter and Wilson, 1962; Pratt and Hibbs, 1964). It seems that only with diets of less than about 67 per cent digestibility, is digestibility itself an important determinant of the intake of dairy cows.

The levels of feeding during rearing can vary over quite a wide range without affecting subsequent milk production, although very low or very high levels may have adverse effects on both animal milk yield and lifetime production.

9.8.1 Feeding calves

The digestive tract of a young calf differes from that of a mature cow (Williamson and Payn,e 1978) and does not function as a ruminant until the calf is a few weeks old.

Most dairy calves in the tropics, whether from *Bos indicus* or *Bos taurus* breeds, are smaller at birth and grow somewhat more slowly than would similar calves in the temperate zones (Payne, 1968a). During the first week, they should be fed no more than 2.8 kg of milk per day and by the fourth week this rate could be raised to 3.7 kg of the whole milk or milk substitute fed. The feeding rate should not exceed 4.5 kg per day as the calves will begin to eat forage as they grow older. At 2 months of age, average calves in the tropics will eat up to 0.45 kg of concentrate per day. If the calves are weaned after three months of age, they will soon eat up to 1.4 to 1.8 kg of concentrates as well as forage. Table 57 shows a suitable mixture of feeds for calf rearing in India (Warner, 1951).

TABLE 57: Calf rearing feed mixture in India

Wheat bran	30 parts
Linseed cake	10 parts
Barley meal	20 parts
Jowar (sorghum sp.)	20 parts
Maize meal	20 parts

Another suitable mixture of feeds that may be available in the tropics is shown in Table 58 (Williamson and Payne, 1978)

TABLE 58: Suitable mixture for calf feed

Coconut meal	50 parts
Groundnut meal	25 parts
Maize meal	25 parts

When calves are fed indoors, special precautions must be taken to see that they receive adequate amounts of minerals and vitamins, either in commercial vitamin-mineral premix or with added fish liver oil to the diet. Calves should always have access to water. It is a mistake to assume that they do not require water because they are being fed large amounts of milk or milk substitutes.

McMeekan (1960) stated that in Ruakura studies in New Zealand, by the time a dairy calf is two months old, it is capable of digesting high quality pasture with an efficiency similar to that of an adult cow. The only limitation in this regard is in relation to the bulk of the ration. Rotational grazing at Ruakura was implemented where the calves were given access to the best pasture on the farm from at least two weeks of age. The feature of this system was the use of pastures which were also grazed by adult stock, with the calves preceding the cows in the rotation.

9.8.2 Feeding heifers

The feeding of a high-quality roughage should be adequate to ensure that these stock grow at a reasonable rate. Payne (1968) concluded that if yearling heifers are fed 0.25 kg per head per day of concentrate as a supplement to forage, they will materially improve their growth, and the time taken to attain sexual maturity will be reduced. Although there is large effect of climatic environment on the growth of cattle, grazing management practice is still a major factor affecting the growth of heifers (Hancock, 1955).

Feeding standards for growing heifers which are widely accepted in the U.S.A. are given previously in Table 55.

9.8.3 Feeding milking cows

During the calving period, a heifer or a cow should not be overfed (Williamson and Payne, 1978). A small quantity of a laxative concentrates such as rice bran is useful feed at this time. After calving, concentrate feeding should be commenced immediately and should reach a peak within approximately 3 weeks. The cow should always be fed a little more concentrate to increase the dry matter intake during the first stage of the lactation. Lactating cows normally use energy (Greenhalgh, 1968) for the three functions of maintenance, milk production and liveweight gain simultaneously. Table 59 shows the daily nutrient requirements of dairy cattle (Esminger, 1969).

9.8.4 Grazing management

Milking cows, like calves and heifers, can be managed either indoors or outdoors or an indoor-outdoor system. It is now generally agreed that, in wet tropics, temperate or cross-bred-type animals are more productive than tropical-type cattle if disease control is adequate and if they are properly managed (Payne, 1968a).

A tropical climate, however, always imposes some degree of stress on milking cattle, and although there will be wide individual variation in yield, there is probably a physiological limit to average milk production. On the other hand, with good husbandry total milk production per unit area of land can be maintained at a very high level.

9.8.4.1 Indoor management

Cows managed indoors often develop long hooves, and these should be trimmed periodically. Bedding should be kept clean, proper ventilation ensured, and strict sanitation should be observed, if this type of management is selected. With the judicious feeding of roughages and concentrates, high levels of animal production can be obtained, although at a high cost, with this system.

TABLE 59: Daily Nutrient Requirements of Dairy Cattle

	Body Weight	Daily Gain	Feed[2]	Protein Total	Protein Digestible	Energy TDN	Energy DE[3]	Energy ME[3]	Ca	P	Caro- tene	Vitamin A	Vitamin D[4]
	(kg)	(g)	(kg)	(g)	(g)	(kg)	(Mcal)	(Mcal)	(g)	(g)	(mg)	(1000 I.U.)	(I.U.)
Growing heifers	50	500	1.0	200	180	1.00	4.4	3.6	4.0	3.0	5.3	2.1	300
	100	650	2.8	430	280	1.90	8.4	6.9	9.6	8.4	10.6	4.2	660
	200	700	5.2	520	380	3.15	13.9	11.4	13.0	12.0	21.2	8.5	1300
	300	600	7.2	660	410	4.10	18.0	14.8	15.0	14.0	31.8	12.7	
	400	600	8.8	700	420	4.60	20.2	16.7	16.0	15.0	42.4	17.0	
	500	400	9.6	750	450	4.80	21.1	17.3	16.0	15.0	53.0	21.2	
Maintenance of Mature Cows	450		6.2	450	270	3.20	14.1	11.6	12.0	12.0	48.0	19.2	
	550		7.8	533	330	3.80	16.7	13.7	15.0	15.0	58.0	23.2	
	650		8.6	608	365	4.20	18.5	15.2	17.0	17.0	69.0	27.6	
	750		9.8	692	415	4.65	20.5	16.8	20.0	20.0	80.0	32.0	
Reproduction (add to maintenance last 2 to 3 months)	400		4.0	400	240	2.4	10.6	8.7	10.0	8.0	22.0	8.8	
	550		5.0	460	275	3.0	13.2	10.8	13.0	11.0	30.0	12.0	
	700		6.0	550	330	3.6	15.8	13.0	16.0	14.0	38.0	15.2	
Lactation (add to maintenance) for cows producing following amounts of milk (4% fat) daily					per kg (2.2046 lbs) milk produced								
More than 35kg (77lb)				88	56	4.20	1.85	1.52	2.8	2.0			
20 to 35kg (44 to 77lb)				78	51	3.70	1.63	1.34	2.4	1.8			
Less than 20kg (44 lb)				70	46	3.30	1.46	1.20	2.2	1.6			

cntd

TABLE 59: cntd

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1 From NRC Pub. 1349, with avoirdupois system added by author of *Animal Science*. Thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, folic acid, vitamin B12 and vitamin K are synthesized by bacteria in the rumen and it appears that adequate amounts of these vitamins are furnished by a combination of rumne synthesis and natural feestuffs.

2 Based on air-dry feed containing 90% dry matter. These figures are only rough estimations since the amount depends on the composition of the ration.

3 ME (metabolizable energy) has been estimated on the basis that 1 gm of TDN has 4.4 kcal of DE (digestible energy) (4.4.Mcal per kg) and that 82% of the DE is available as ME. The ME values can be converted to DE by multiplying by 122.

4 While vitamin D is known to be required, quantitative data are not available for growing animals above 200 kg in body weight and for maintenance and reproduction. Animals exposed to direct sunlight or fed sun-cured forages do not need supplemental Vitamin D.

9.8.4.2 Outdoor management

With outdoor management, particularly in the muddy conditions lthat occur in wet tropics, cows' hooves often develop soft pads which are invaded by infectious organisms that cause lameness. It is a good practice to walk these cattle through a foot-bath containing a copper sulphate or formalin solution at regular intervals, even daily, as routine measures, perhaps as they leave the milking bail.

Cows managed with outdoor pasture may develop the habit of suckling each other and individuals will suckle themselves. This habit can be prevented by attaching a short length of chain to one or two rings in the nose.

9.8.4.3 Grazing management outdoors

It has been observed in the Philippines that crossbred cattle, managed under an extremely rapid type of rotational grazing system, graze for longer periods during the day when grasses are young and succulent (Williamson and Payne, 1978). It has also been noted that when dairy cattle graze the same area for more than two successive grazing periods, the cows grazed the fresh grass first but progressively spent less total daylight hours grazing and spoiled a great deal of grass by trampling it when it was long.

Rotational grazing should be over as many small paddocks as is practicable, ideally about twenty in number. However, the cattle should be grazed in any one field for as short a time as possible; hence they are always able to obtain new and succulent forage. The shortest possible time is that when a high degree of pasture utilization is obtained, probably by rotating cattle once every 15 to 20 days.

In New Zealand, 3 to 4 months prior to calving, a Jersey-type cow requires 4 to 5 pasture dry matter each day (Bryant, 1970) in order to maintain her liveweight. Most pastures in New Zealand's major dairying areas are capable of producing between 500 to 700 kg milkfat per ha. from grass annually. Features of these very high producing farms include:

(1) stocking rates of 3.4 of cows per ha. to ensure the harvesting by grazing of most of the pasture grown.

(2) low replacement rates with well-reared, genetically-superior young stock.

(3) stock in good condition at calving, achieved by optimum winter management and judicious selection of times for drying-off and for calving.

(4) pasture management that results in full feeding in early lactation, and the efficient conservation of any surplus growth as silage or hay.

(5) a flexible summer-autumn management that absorbs the uncertainties of summer with a minimum loss of profit.

CHAPTER X

MILK HANDLING AND MILK TECHNOLOGY

A technical approach to handling food in a young country (Siegenthaler, 1972), usually under adverse climatic and other conditions, requires considerable adaption of the usual way of thinking in the temperate zone. In the latter, society requires that everything used in the daily diet meets stringent standards. All methods of technology should be utilized to improve food and make it better, but due attention should be paid to the given conditions in the environment, including the sociology and the nutritional awareness of the people. The first step in improving the quality of foods (McDowell, 1972) is to orient the attitude of the people to change; without the support of the people, the quality of milk products will become poorer rather than improve.

10.1 Cow handling at milking-labour aspects

Milking has always been regarded as a time-consuming tedious task, carried out twice daily by the dairy farmer. Albright (1964) observed in the U.S.A. that one man, handling 90 cows on a feed-lot system, spent 47 per cent of his working time in preparation, milking and cleaning-up. Pitman (1960) recorded from studies of 6 dairy farms with herds ranging from 104-156 cows, that 51 per cent of the total working time was spent in milking. This shows (Kaye *et al.*, 1972) the need to look at the organisation of milking with its labour requirements from start to finish.

Even where labour is more readily available, as in the

Philippines, good labour organisation at milking is important.

10.1.1 Milk hygiene

Measures to provide adequate milk supplies for consumers, and to ensure the safety and cleanliness of the product, (Rice, 1965) are of paramount importance. Problems inherent in achieving this aim of good hygienic quality are poverty and illiteracy of producers, the small quantity of milk produced by each cattle owner, unhygienic utensils, dust, contaminated and inadequate water supplies, and high ambient temperatures during most of the year. Obviously, the raw milk is of poor keeping quality because of the presence of micro-organisms which either spoil the milk, or are pathogenic, or both.

10.1.2 Cleaning of equipment

Many investigations have shown that improperly-cleaned dairy equipment far outweigh any other single factor in causing bacterial contamination of milk during its production. The rate of spoilage (Rice, 1965) depends on this initial contamination and the temperature of storage. In tropical climates, even more emphasis must be placed on control of these factors than in cool climates, and more adequate quality checks are required.

When milk of poor bacteriological quality (plate count over 30,000 bacteria/ml) was being produced, Major (1962) found much higher contamination from the rubberware of the milking machine than from metal parts, the ratio ranging from 10:1 to as high as 117:1. However, the range was always less than 3:1 when the milk was of satisfactory bacteriological quality. Oliver and Sample (1962) found that, associated with an improved routine with unskilled labour, an improved product could be obtained by chemical sterilization of equipment with the quaternary ammonium compounds. They also mentioned the risk of contaminated bore water, also a hazard in most warm climates.

10.1.3 Weed taint

The occurrence of prolific seasonal growth of certain weeds will cause taints (Rice, 1965) to be imparted to the milk of cows which ingest them. Armitt (1964) recommended that suspect pastures and crops should be lightly grazed by the milking herd, and the young and the dry stock be used to complete the grazing, to minimize the taint in the milk and cream produced. Weedy areas should be grazed for two days, and the herd then removed to a weed-free area for one day before being returned again to weedy areas. The milking animals should be removed from milk-tainting crops at least four hours before milking. While vacreation of milk and cream will remove many feed taints from the milk at the factory, the essential oils from many plants remain unaffected by this process (Conochie, 1950). The ultimate solution (Rice, 1966) seems to depend on control on the farm by the use of better pasture plants which are capable of competing with, even eliminating, the offending weeds.

10.1.4 Milking sheds

Housing, of course, is not necessary in warm climates and therefore, in countries where organized rural milk production is being developed, dairy buildings need not be as elaborate and costly as those in cold climates. However, siting, drainage, ventilation and protection of the quality of milk are most important aspects to be considered in connection with dairy farm buildings in hot climates, especially where heavy monsoon rains may be encountered. Adequate supplies of water, both hot or cold, should be provided at the milking shed to enable hygienic practices to be followed (Rice, 1966).

10.1.5 Milk cooling

Barrett and Larkin (1974) stated that most common sources of bacterial contamination of milk are the cow, the milker and the utensils. Most milk produced is strained before it leaves the farm, but this does not improve, and may seriously reduce, the milk quality by adding bacteria. The strainer must be chosen carefully as the bucket, and straining must be through a clean cotton-wool milk strainer used only once. If the milk can be cooled rapidly to below 15°C, bacterial growth is slowed; if the milk can be cooled to below 5°C, bacterial growth can be arrested.

10.1.6 Transport and distribution

In the year 1962, the Philippines was still encountering a problem with regard to transport of milk because of no organized system which might speed up the transport of milk (Villarta, 1962). However, lately, dairy farmers organized themselves into co-operatives, with the assistance of the government, in such a way that all milk produced is collected and transported on a co-operative system and in a relatively speedy manner.

Even after the milk has been manufactured into dairy products, the storage conditions are critically important if the dairy products are to be maintained in perfect condition. The storage life, and specific temperatures required for various dairy products, are shown in Table 60.

In summary, milk hygiene in the less-developed dairy countries is sometimes much below tolerable standards. On the other hand, in some warm countries with an organized dairy

TABLE 60: Storage Life of Dairy Products

Product (commercial pack)	Approximate storage life at specific temperatures	Critical or dangerous storage conditions
Butter (in bulk)	1 month @ 40°F 12 months @ -10°F	Above 50°F., or damp or wet storage
Butteroil (sealed, full tins; maximum moisture 0.3%)	3 months @ 70°F 6 months @ 50°F 9 months @ 32°F	Above 75°F
Anhydrous milk fat (sealed, full tins; maximum moisture 0.2%)	3 months @ 70°F 6 months @ 50°F 9 months @ 32°F	Above 75°F
Ghee (sealed, full tins)	6 months @ 90°F 9 months @ 70°F 18 months @ 40°F	Above 90°F
Cheddar cheese	6 months @ 40°F 18 months @ 34°F	Above 60°F or below 30°F
Processed cheese	3 months @ 70°F 12 months @ 40°F	Above 90°F or below 30°F
Grated cheese (in moisture-proof pack)	3 months @ 70°F 12 months @ 40°F	Above 70°F, or above 17% moisture in the product
Sterilized whole milk	4 months @ 70°F 12 months @ 40°F	Above 90°F or below 30°F
Nonfat dry milk, Extra Grade (in moisture-proof pack)	6 months @ 90°F 16 months @ 70°F 24 months @ 40°F	Above 110°F
Dry whole milk, Extra Grade (gas pack; maximum oxygen 2%)	3 months @ 90°F 9 months @ 70°F 18 months @ 40°F	Above 100°F
Sweetened condensed milk	3 months @ 90°F 9 months @ 70°F 15 months @ 40°F	Above 100°F or below 20°F, or dampness sufficient to cause can rusting
Evaporated milk	1 month @ 90°F 12 months @ 70°F (cases to be inverted every 2 months) 24 months @ 40°F	Above 90°F, or below 30°F, or dampness sufficient to cause can rusting

Compiled by Dairy and Poultry Division, Foreign Agricultural Service from material supplied by Standardization Branch, Consumer and Marketing Service and Eastern Utilization Research and Development Division of Agricultural Research Service, USDA, FAS M-172, 1966 industry, milk hygiene practice compares favourably with that in the most important dairying countries. The attainment of high standards in a warm climate does, however, involve special attention being given, in particular, to the cleaning of dairy equipment, and to the cooling and storage of milk and cream by means of farm refrigeration.

10.2 Milk technology

Development in dairyfarming and in dairy product manufacture in some tropical countries show that even medium technological progress (Rice, 1966) enables milk and milk products of satisfactory quantity and quality to be produced in warm climates. However, either directly or indirectly, warm climates strongly influence the milking performance of dairy cattle and also pose problems of handling and treatment of milk and milk products.

10.2.1 Sterilization

Milk is heat-sterilised in glass bottles in certain tropical dairies. The treatment involves heating the sealed bottles of homogenized milk to 104.5 - 110^{o}C (Williamson and Payne, 1978) for 20 to 30 minutes, sufficient to ensure that it keeps for 7 days or more (Davies, 1965). Ultra-high-temperature (UHT) treatment of milk is a relatively new process by which the milk is heat-treated to increase both its safety as a food and its keeping quality. Aseptic packaging follows this treatment. This milk is heated to between 130 to 135^{o}C for a few seconds, and then aseptically packed (Burton, 1965).

Varma *et al.*, (1959) asserted that raising the temperature of pasteurisation above 165^{o}F for 15 seconds would neither lower the bacterial count nor improve the keeping quality of pasteurized milk in India. Bacterial plate count should be kept below 10,000/ml, and thermoduric bacteria virtually eliminated.

10.2.2 Processing

Technical workers have developed many milk products, in tropical areas which are peculiar to a local situation and climate. The manufacture of such products soon after the milk has been produced is necessary because, in warm climates, coagulation - or "souring" - occurs quickly as a result of bacterial activity (Williamson and Payne, 1978).

10.2.2.1 Toned milk

Toned milk initially contained 3.5 per cent fat and 9.0 per cent solids-not-fat (Khurody, 1962) but several years later its fat content was reduced to 3.0 per cent (Rice, 1966). Mixing buffalo milk, with an average fat content of 6 per cent, with milk reconstituted from dried skimmilk, gives a product similar to that of the most European whole milk and is termed "toned milk" (Khurody, 1962). Milk with a fat content of 1.5 per cent, and a solids-not-fat of 10 per cent is distributed free to school children in Bombay, India.

10.2.2.2 Filled milk

Filled milk is produced by dissolving dried skim-milk (Briackman, 1962) in water, mixing it with vegetable oils, and then pasteurising the mixture. The substituted fat imparts a distinctive flavour. Some countries have a legal protective measure which bans the production of such filled milk.

10.2.2.3 Sterilized milk

In many countries, sterilized milk, which has a good shelf-life without refrigeration is popular with some consumers, but because of its heated taste, it is not acceptable to other people. However, its good keeping quality and ability to be transported and stored without refrigeration appear to be offset by the problem of the return of the bottle, higher costs and some adverse reactions by the consumers.

10.2.2.4 Butter and butter derivatives

In India, it was found out that butter made from vacreated cream had a better flavour than that of bulk butter manufactured from either flash or holder systems pasteurized cream. The addition of a steam pressure head, with triple vacreation resulted in marked improvement in butter quality.

An informative account of the manufacture and storage of ghee in India was given by Dastur and Banuji (1948). They briefly summarized the five methods in use, modifications to each of which are adopted in practice, as follows:

(1) Desi method - milk is converted into curds, butter is isolated and this is heated to obtain ghee.
(2) Creamery butter method - cream is obtained from milk by the use of a mechanical separator. Butter is prepared from this cream and then it is melted to ghee.
(3) Cream method - thick cream is prepared by the use of a mechanical separator and, after souring, is heated directly and ghee is obtained.
(4) Vacuum pan method - creamery butter or thick cream is freed from water by heating under vacuum at a low temperature until pure butterfat is obtained.
(5) Direct from milk - this is prepared by churning cooled milk after heating it first. This method is used only in rare instances and hence is not of commercial importance.

10.2.2.5 Cheese

Pasteurization of the milk may be regarded as essential for the manufacture of cheese of acceptable commercial quality in warm climates. Effective cooling of the milk on the farm in order to retard bacterial multiplication is another requirement unless the milk is delivered twice daily to the factory (Nichols *et al.*, 1946; Rice, 1962 and 1964).

10.2.2.6 Other products

10.2.2.6.1 Cultured cream

Cohen (1956) summarized the method of manufacture of cultured cream which has a fat content of 15 per cent. Whole milk and cream are mixed to standardize the fat percentage, and the standardized mix is warm-bath-pasteurized at 170^{O}F for 15 seconds and homogenized at 1,500 lb/sq. in. It is then cooled in a plate cooler to 70^{O}F, run into an insulated tank, started is added, and, the mix incubated for 15-18 hours to an acidity of 0.66 to 0.72 per cent. The ripened cream is finally run by gravity through specially designed valves into bottles. An alternative, but less satisfactory method is to fill the bottles with the pasteurized, homogenized and cooled cream immediately after the starter is added, and to store the bottles in a room at about 10^{O}F until the correct acidity is reached or the bottle removed.

10.2.2.6.2 Infant food

Chandrasekhaen *et al.*, (1959) have outlined methods of preparation of a powdered infant food in which buffalo milk is used to replace cows' milk.

In summing-up, it must be admitted that the processing of milk products on a factory-scale enterprise in tropical areas has not made spectacular progress. Nevertheless, there is a trend to establish milk pasteurization factories in many tropical areas, notably in the milk colonies of Bombay, Calcutta, Madras in India, Baghdad in Iraq, and Karachi in West Pakistan. Then, plans for the production of recombined milk are now well-established in the Caribbean area and in some parts of Southeast Asia. However, the bulk of the milk produced in countries such as India, Pakistan, Turkey and in Southeast Asia is still processed - if it is processed at all - on a domestic scale.

CHAPTER XI

SUMMARY AND RECOMMENDATIONS

A review of the existing conditions, as well as a discussion of problems besetting milk production in tropical countries with special emphasis on the Philippines has been presented. Understanding the prevailing conditions, the current management practices, as well as the inherent problems in tropical dairying, will help to clarify the recommendations which have been made. If these were implemented by the government, and the private sector engaged in dairying, the production and overall efficiency of the industry would be improved.

Tropical countries produce only 21 to 34 per cent of the world's milk output, in spite of the fact that 70 per cent of the world's cattle and buffalo population, which is the major source of milk, is located in the tropics. This is a clear indication that milk production in tropical countries is very low. Then, the production, handling and treatment of milk and milk products involve specific problems which differ from those in temperate climates.

Most of the problems which tend to lower the production of milk include the interactions of climate, animal disease, breeding, feeding and management practices. Furthermore, dairying in most countries in the tropics is still unorganised, primitive and carried out on a small scale. With this situation, the majority of the tropical countries resort to importing milk and milk products from temperate countries to augment the local milk supply.

In the Philippines, for example, it was noted that about

90 per cent of the milk and milk products consumed are imported. In addition, the processing section of the industry depends to a very large degree on imported raw materials. According to the most recent information available, there are 28 government-owned dairy farms scattered throughout the country and operated by the Bureau of Animal Industry of the Ministry of Agriculture, the Dairy Training and Research Institute of the University of the Philippines at Los Banos, and the State Colleges and Universities, plus 22 privately-owned dairy farms.

11.1 The Effect of Climate as a Problem

The direct effects of high ambient temperature and solar radiation on cattle are well-known. The normal reactions of cattle under heat stress is to limit food intake followed by reduced milk flow and growth rate. It is therefore worth examining possible methods of reducing "heat load" in order that animals could more or less increase their production. Such methods might well include the following:

(1) Grazing cattle under coconut palms. Since most cattle are best adapted to a temperate climate, and the Philippines is a major exporter of coconut products, the idea of grazing cattle in the shade of the coconut is sensible. Studies have shown that the effects of solar radiation are reduced by the shade, and the animals graze in a pattern similar to that of cattle on open pastures in the temperate zone.

(2) Giving productive cattle night grazing. This will help to compensate for the lower feed intake during day time.

(3) Provision of shelter by building sheds, and using water sprays and forced air drafts if warranted, in order to reduce animals' heat load.

(4) Cooling water from 31^{o} to 18^{o}C. This will decrease water consumption and will improve liveweight gain. Payne (1955) estimated that cooling the water decreased the "heat load" by 10 per cent of the basal heat load daily.

(5) Finally, feeding animals with limited roughage only. This system will reduce heat production. It should be borne in mind that concentrates are needed in the diet of the animal to balance the ration in regard to protein content and to provide energy.

11.2 Genetic Improvement of Stock as a Problem

Several breeding systems, aimed at improving the genetic merit of indigenous breeds, have been studied. Also, studies on the acclimatisation of exotic breeds have been carried out.

It has been shown that cattle are best acclimatized to the temperate environment regions of the world. It is therefore a very difficult task to maintain the productivity of European-type cattle under tropical conditions. Hence attention in breeding programmes has been focussed on the following procedures:

(1) The utilization of indigenous cattle that are already well-adapted to the environment by selection for high productivity.

(2) The importation of highly productive, temperate-type cattle followed by selection for adaptability to the tropical environment.

(3) The importation of highly productive, temperate-type cattle, or use of their semen, for upgrading less-productive indigenous cattle.

Recent studies indicate that crossbreeding with European breeds such as Friesian, Ayrshire and Jersey, with exotic breeds such as Red Sindhi and Tharparker, produces animals exhibiting good performance in terms of production. Stock with about 3/4 European blood and 1/4 Exotic blood display the highest production level. It appears that the proportions of crosses just mentioned will increase milk performance, but will decrease reproductive efficiency.

11.3 Nutrition as a Problem

Pasture improvement is vital for providing additional, an- relatively cheap, energy and protein for dairy cows, so that their milk can provide much-needed animal protein in our daily diet. It is known that, although indirectly, climatic environment will affect the nutritive value of the sward. In addition, in this context, the voluntary feed intake of highly digestible pasture by grazing stock is a critical factor in determining not only the peak production of milk but also the total yield over the lactation in dairy stock. Because the digestibility of the forage consumed has a direct effect on the total voluntary intake, and because tropical grasses decline so quickly in digestibility with increasing maturity, it is desirable to provide forage of optimal composition over the critical early to mid-lactation period, if not over the whole of the season. The following procedures are therefore suggested:

(1) The ration fed to an animal should be adjusted to the requirements of its productive functions. It should be based on adequate and correct information of the nutrient content and feeding value of its components in the ration, in relation to the production requirements of the stock.

(2) It is now generally accepted that the basis of efficient

production must be the introduction of suitable legumes into the sward so that the stock will have additional supplies of protein in the ration. The introduction of these legumes will also result in an increase in the levels of soil nitrogen, which will, in turn, increase total dry matter production. Legumes are known to contribute about 250 kg nitrogen per hectare (De Guzman, 1975). Legumes are also more tolerant of drought and produce more greenfeed than ordinary forage. Furthermore, they contain a substantial content of protein and minerals and thus improve the overall quality of feed. The recommended forage, based on its adaptability and nutritive value under tropical conditions is a Para grass and *Centrosima pubescens* mixture.

(3) The application of fertilizer greatly improves the yield and quality of herbage, and permits more frequent grazing over the season.

(4) Stocking rates should be adjusted in accordance with the quality and productivity of the pastures.

(5) Sowing swards on a crop basis, with appropriate cultural and management practices, such as fertilizer application, irrigation and approved rotational grazing.

11.4 Diseases as a Problem

Most diseases of a general nature influence the rate at which milk is secreted, or the composition of the milk. Furthermore, environmental conditions are ideal for the spread of diseases and parasites in tropical zones. Although diseases are widespread in many parts of tropical countries, at present they are being gradually brought under control.

In this context, measures to be followed include: quarantine of newly-imported animals, periodic immunization of animals against those diseases that are prevalent, and rigid checking of animals as to their behaviour and performance.

11.5 Herd Management as a Problem

It is widely recognized that the productivity of dairy cattle can be raised by improved management. In improving animal management, emphasis should be placed on known sound practices of rearing young stock and heifers, handling of milking cows, and general feeding and grazing management. This includes:

(1) Restricted breeding season

(2) Co-ordinating herd management practices with the seasonal feed supply ("dry" cows during dry season).

(3) Weaning calves at 7 to 9 months to give cows a rest before the next calf is due.

(4) Supplemental feeding of weaner calves, and

(5) Use of records of performance as a guide to selection and for culling.

11.6 Milk Hygiene and Milk Technology as a Problem

Since milk hygiene is considered as sometimes below tolerable standards, it is suggested that legal and marketing standards should be set by the government responsible for milk production, and provision for facilities for milk treatment, including pasteurisation and refrigeration, should be established. Farmers engaged in dairying should learn the importance of proper hygiene in handling milk and milk products through advisorships, and through seminars conducted by the experts of dairying in a particular country. In addition, the processing of dairy products shoul be established on a co-operative basis, with operating standards specified and inspected by government specialists.

In summation, improvement of dairying in tropical countries is possible and potentially has a great future. It is necessary to adapt the techniques and technology from dairying in temperate climates. Ultimately, maximum production in tropical areas could be greatly increased, and the problem of malnutrition among children which is common in the tropics could be reduced very significantly.

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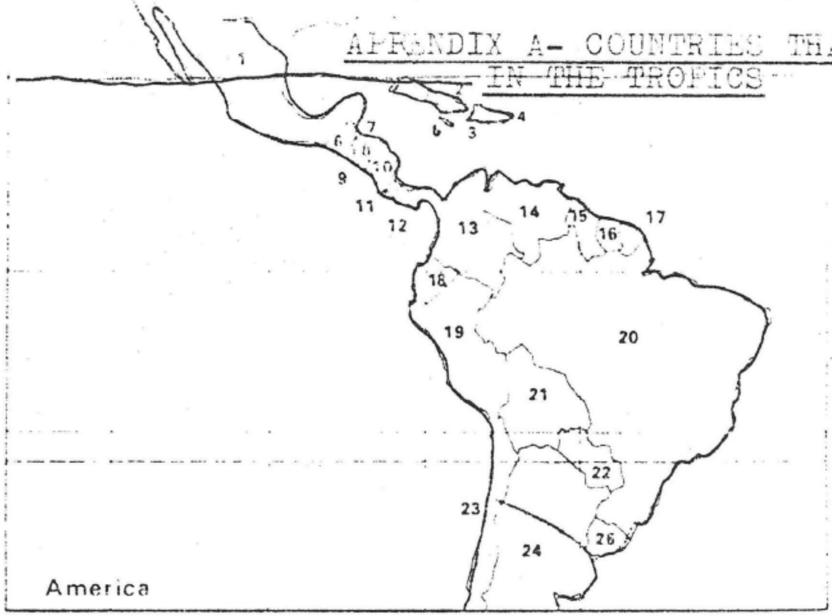
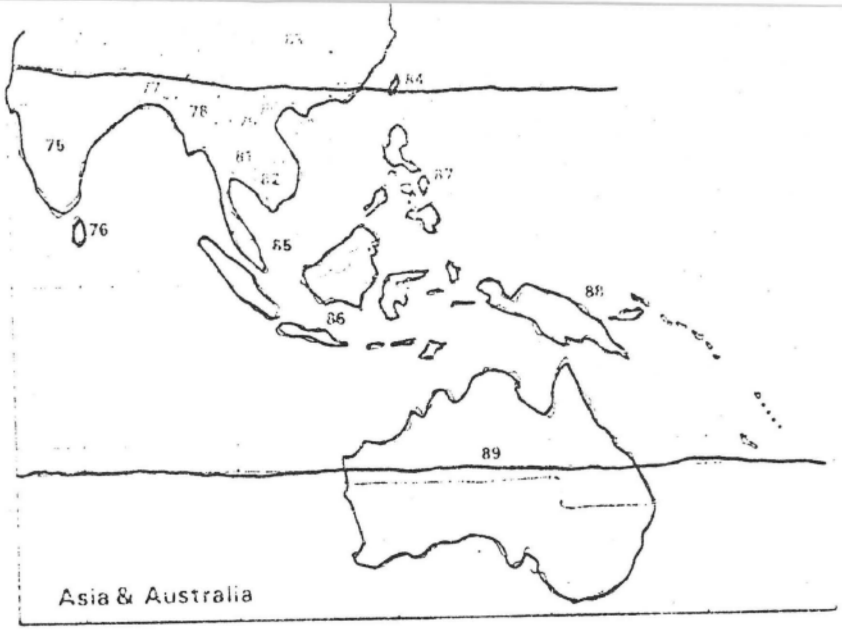
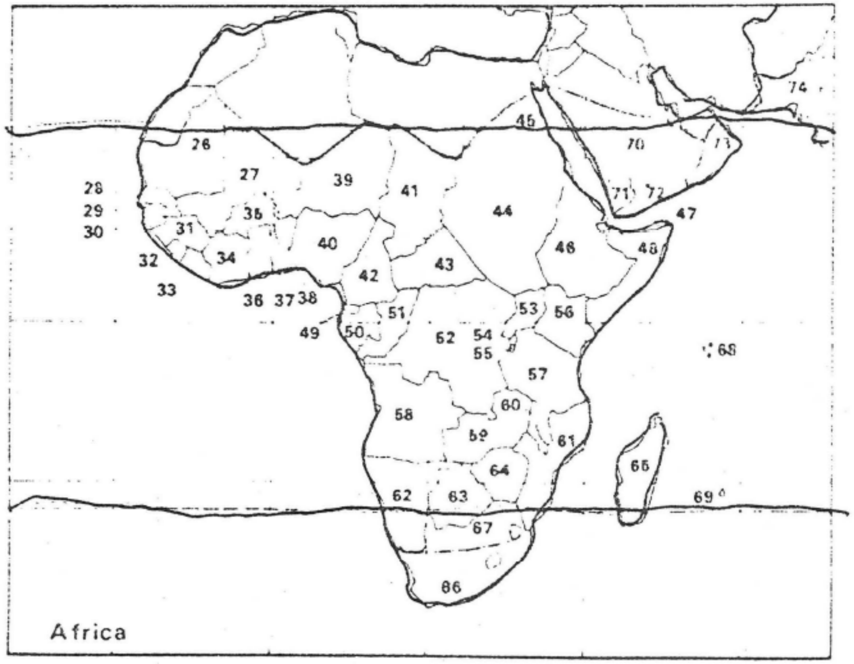
APPENDIX A- COUNTRIES THAT LIES IN THE TROPICS



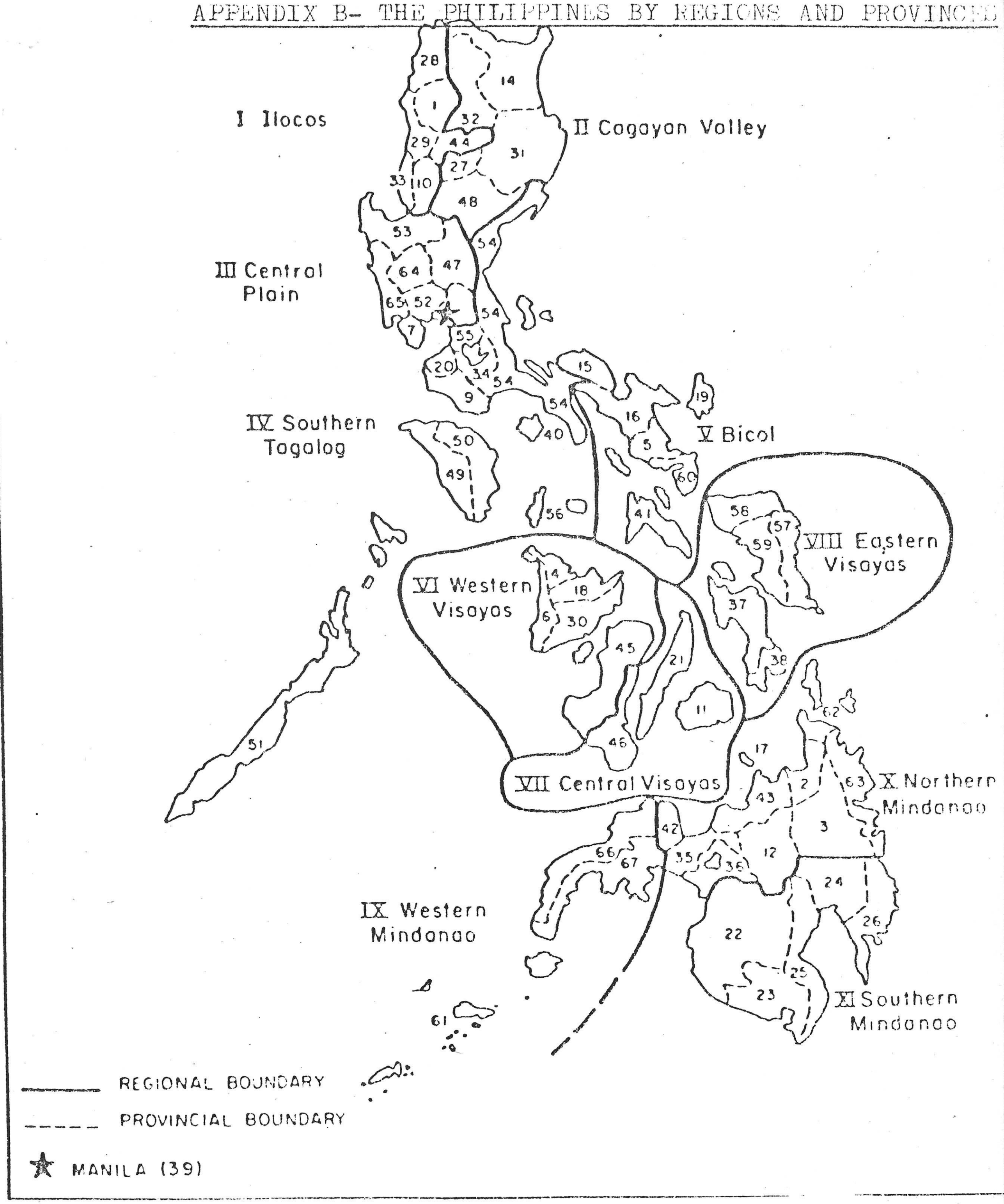




THE TROPICS

1 Mexico
2 Cuba
3 Haiti
4 Dominican Rep.
5 Jamaica
6 Guatemala
7 Belize
8 Honduras
9 El Salvador
10 Nicaragua
11 Costa Rica
12 Panama
13 Colombia
14 Venezuela
15 Guyana
16 Surinam
17 French Guiana
18 Ecuador
19 Peru
20 Brazil
21 Bolivia
22 Paraguay
23 Chile
24 Argentina
25 Uruguay
26 Mauritania
27 Mali
28 Senegal
29 Gambia
30 Guinea Bissau
31 Guinea
32 Sierra Leone
33 Liberia
34 Ivory Coast
35 Upper Volta
36 Ghana
37 Togo
38 Dahomey
39 Niger
40 Nigeria
41 Chad
42 Cameroun
43 Cen. Afr. Rep.
44 Sudan
45 Egypt
46 Ethiopia
47 F.T.A.I.
48 Somali Rep.
49 Equat. Guinea
50 Gabon
51 Congo Rep.
52 Zaire
53 Uganda
54 Rwanda
55 Burundi
56 Kenya
57 Tanzania
58 Angola
59 Zambia
60 Malawi
61 Mozambique
62 Namibia
63 Botswana
64 Rhodesia
65 Madagascar
66 South Africa
67 Swaziland
68 Seychelles
69 Mauritius
70 Saudi Arabia
71 Yemen
72 Dem. Rep. Yemen
73 Oman
74 Pakistan
75 India
76 Sri Lanka
77 Bangladesh
78 Burma
79 Laos
80 Vietnam
81 Thailand
82 Khmer Rep.
83 China
84 Taiwan
85 Malaysia
86 Indonesia
87 Philippines
88 Papua
89 Australia

APPENDIX B- THE PHILIPPINES BY REGIONS AND PROVINCES



1. Abra
2. Agusan del Norte
3. Agusan del Sur
4. Aklan
5. Albay
6. Antique
7. Bataan
8. Batanes
9. Batangas
10. Benguet
11. Bohol
12. Bukidnon
13. Bulacan
14. Cagayan
15. Camarines Norte
16. Camarines Sur
17. Camiguin
18. Capiz
19. Catanduanes
20. Cavite
21. Cebu
22. Cotabato
23. Cotabato, South
24. Davao del Norte
25. Davao del Sur
26. Davao Oriental
27. Ifugao
28. Ilocos Norte
29. Ilocos Sur
30. Iloilo
31. Isabela
32. Kalinga-Apayao
33. La Union
34. Laguna
35. Lanao del Norte
36. Lanao del Sur
37. Leyte
38. Leyte, Southern
39. Manila
40. Marinduque
41. Masbate
42. Misamis Occidental
43. Misamis Oriental
44. Mountain Province
45. Negros Occidental
46. Negros Oriental
47. Nueva Ecija
48. Nueva Vizcaya
49. Occidental Mindoro
50. Oriental Mindoro
51. Palawan
52. Pampanga
53. Pangasinan
54. Quezon
55. Rizal
56. Romblon
57. Samar, Eastern
58. Samar, Northern
59. Samar, Western
60. Sorsogon
61. Sulu
62. Surigao del Norte
63. Surigao del Sur
64. Tarlac
65. Zambales
66. Zamboanga del Norte
67. Zamboanga del Sur

APPENDIX C: The Dairy Training and Research Institute at University of the Philippines at Los Bauos Laguna, Philippines

Established in 1962, the Dairy Training and Research Institute provides services and facilities for instruction, research, training, and extension in dairy sciences.

It is the site of the Dairy Training and Development Centre for Southeast Asia and the Far East and is assisted by the Food and Agriculture Organization and the Danish International Development Agency.

A pilot plant set up by the DTRI provides facilities for training dairy plant personnel and serves as a research laboraotry. It was set up with assistance from United Nations Development Program (UNDP) Special Fund and Colombo Plan.

A milk collection scheme for research and extension purposes was launched by the DTRI in 1969, designed to tap and develop the potential for milk production of small farms.